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VIBRATION TESTING OF THIOKOL CHEMICAL CORPORATION FLTSATCOM APOGEE KICK MOTOR TE-M-364-19 (SYSTEM S/N 19006 Q-2)

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VON KARMAN GAS DYNAMICS FACILITY
ARNOLD ENGINEERING DEVELOPMENT CENTER
AIR FORCE SYSTEMS COMMAND
ARNOLD AIR FORCE STATION, TENNESSEE 37389

May 1977

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Final Report for Period 5 - 17 January 1977

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Prepared for

SPACE AND MISSILE SYSTEMS ORGANIZATION (SKF)
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NOTICES

APPROVAL STATEMENT

This technical report has been reviewed and is approved for publication.

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20 ABSTRACT (Continue on reverse side if necessary and identify by block number)

A Fleet Satellite Communications (FLTSATCOM) System Apogee Kick Motor (AKM), Thiokol Chemical Corporation Serial Number 19006 (Q-2), was tested in the Impact, Vibration, and Acceleration Test Unit (IVA), von Kármán Gas Dynamics Facility (VKF) in support of FLTSATCOM Qualification Testing. The objective of the test was to subject the AKM to a launch-simulated dynamic environment preceding altitude firing of the motor in the Propulsion

20. ABSTRACT (Continued)

Development Test Cell (T-3), Engine Test Facility (ETF), AEDC. The dynamic testing consisted of a 1.0-g (0 to peak) sine sweep followed by a nominal 9.25-g (rms) random vibration input in each of two orthogonal axes. All dynamic input requirements to the AKM were completed satisfactorily. Pretest and posttest inspection of the AKM revealed no problems attributable to the imposition of the dynamic environment. This was the third FLTSATCOM AKM test conducted in the IVA test unit in support of the motor development and qualification program.

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PREFACE

The work reported herein was conducted by the Arnold Engineering Development Center (AEDC), Air Force Systems Command (AFSC), at the request of the Space and Missile Systems Organization (SAMSO/SKF), under Program Element 920B09. The motor was provided by the Thiokol Chemical Corporation/Elkton Division. The Thiokol test engineer was Mr. Ron Jamison. The results of the test were obtained by ARO, Inc., AEDC Division (a Sverdrup Corporation Company), operating contractor for the AEDC, AFSC, Arnold Air Force Station, Tennessee, under ARO Project Number V41T-26A. The authors of this report were R. E. Alt and J. T. Tosh, ARO, Inc. The data analysis was completed on February 4, 1977, and the manuscript (ARO Control Number ARO-VKF-TR-77-9) was submitted for publication on February 18, 1977.

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1.0 INTRODUCTION

The Thiokol Chemical Corporation (TCC) Apogee Kick Motor (AKM) is a subsystem of the Fleet Satellite Communications (FLTSATCOM) System spacecraft. The motor is a solid propellant rocket motor used to inject the spacecraft into a near geosynchronous orbit by firing the AKM near the apogee of the transfer orbit.

Vibration testing of the AKM was required on one development motor and on two qualification motors. The test programs on the FLTSATCOM motors required that they be subjected to dynamic environments of both sinusoidal and random vibration prior to test firing. The development motor (D-2) and first qualification motor (Q-1) had been tested previously at AEDC (Refs. 1 and 2).

The test of the second qualification motor, S/N 19006, consisted of the following:

1. One sinusoidal vibration sweep at 1.0 g (0 to peak) from 5 to 2,000 Hz at a rate of two octaves per minute in both the thrust and lateral axes, and

2. Random vibration at 9.25-g rms for a duration of 3 min in both the thrust and lateral axes.

The dynamic testing was conducted in the Impact, Vibration, and Acceleration (IVA) Test Unit of the von Kármán Gas Dynamics Facility (VKF) at AEDC.

2.0 APPARATUS

2.1 TEST ARTICLE

The FLTSATCOM Apogee Kick Motor (Fig. 1) is an elongated, spherical, solid-propellant motor approximately 38 in. in diameter and 66 in. long, containing approximately 1,860 lb of propellant. The motor is equipped with a submerged, contoured-type nozzle and a pyrogen-type igniter complete with an electromechanical safe and arm (S&A) device. The overall weight of the motor is approximately 2,010 lb.

2.1.1 Motor Case

The motor case is a 36.7-in.-diam pressure vessel made of titanium alloy and consisting of two hemispherical domes welded to a short, cylindrical center section. The motor attachment flange is an integral part of the cylindrical section and contains 48 equally spaced mounting holes. The motor case is internally insulated to provide thermal protection during motor operation and to limit the case external temperature during postfire thermal soak.

2.1.2 Propellant

The motor is loaded with Thiokol TP-H-3062 composite ammonium perchlorate propellant. The propellant contains 86 percent solids: 70 percent by weight of ammonium perchlorate and 16 percent by weight of aluminum powder. The remaining 14 percent is a carboxyl-terminated polybutadiene (CTPB) fuel binder. Bonding between the propellant and the case insulation is enhanced by an imine epoxy-cured CTPB liner. The propellant grain is an eight-point star case-bonded design.

2.1.3 Igniter and Safe and Arm Device

The igniter assembly and S&A device are mounted in a threaded boss at the case head end. The ignition train consists of two initiators which ignite a small boron/potassium nitrate charge which, in turn, ignites the pyrogen igniter cartridge. The electromechanical S&A device is equipped with a blocking rotor that interrupts the ignition train between the initiators and the boron charge when it is in the safe position. The S&A device is equipped with a plenum which can contain the gases discharged from the initiators when it is in the safe position.

2.1.4 Nozzle

The motor has a composite contoured nozzle which is partially submerged within the motor case. The nozzle is constructed of carbon cloth/Fiberglas® phenolic material as the structural member, an asbestos phenolic to thermally protect the structure within the motor case, a carbon-cloth rosette throat backup structure, a Graph-I-Tite G-90® throat insert, and a titanium-alloy closure ring (bonded to the exit cone) which attaches the nozzle to the rocket motor case. A round polyurethane foam throat plug is used to prevent an open grain configuration.

2.2 TEST UNIT

The IVA Test unit consists of a vibration system, a shock machine, and a centrifuge. The equipment is contained in a single area to facilitate test operations and minimize equipment handling. The equipment control room is separated from the test area by a reinforced concrete wall. The impact and acceleration test equipment were not used on this program and are not described.

2.2.1 Vibration System

The vibration system consists of a Ling electrodynamic shaker, Ling power amplifier, Spectral Dynamics Corp. sine vibration control equipment, and Ling random vibration control system. The shaker (Ling Model A249) is a wide-frequency-band electrodynamic force shaker capable of producing a force rating of 30,000 lbf in the sine mode and 32,000 lbf when operated in the random mode. The shaker operates in a 5- to 2,000-Hz frequency range from either a sine or random waveform input, converting the electrical power supplied into mechnical force.

The sine vibration signal and rate of sweep are supplied by a sweep oscillator (Spectral Dynamics Corp. Model SD 104) through a servomonitor (SD 1056) located in the control room. The output from the servomonitor is fed to the power amplifier (Ling Model PP 175/240) and then to the shaker. A control accelerometer located on the test fixture senses the vibration and sends a signal through conditioning amplifiers to the tracking filter (SD 1012B). There, the signal is filtered by preselected filters with specified bandwidths. From the tracking filter unity gain output, the signal is fed to the servomonitor. For multilevel test conditions, the control signal is fed from the tracking filter unit gain output through the SD 115 automatic level programmer to the servo monitor. At the servo monitor the control signal is automatically compared, for control purposes, to a preset g level. The servomonitor automatically adjusts its ouput to provide a constant acceleration level in accordance with a preset value.

The random vibration input signal is supplied by the random vibration analyzer/equalizer system (Ling Model ASDE-80) located in the test control room. This system analyzes the shaker acceleration output and equalizes internally generated random noise to the desired spectral density. It covers the frequency range from 10 to 2,025 Hz in 85 channels with bandwidths of 25 Hz or less. The ten channels at the low end of the frequency range have bandwidths from 10 to 18 Hz.

The control system allows automatic control of the accleration spectral density by individual servoamplifiers in each channel. The output of the random noise generator is shaped to the desired spectral density by the control system, then passed through preamplifiers to a power amplifier. The power amplifier increases the signal power level and feeds it to the electrodynamic shaker, which converts it into mechanical force, which drives the test article. The power spectral density input to the test article is continuously monitored during testing with a Real Time Analyzer (Spectral Dynamics Model 301D) to verify that the power spectral density is within the required operating tolerances.

When testing is performed in the lateral axis, the test fixture is mounted on hydrostatic bearings (Team Corp. Models 1830T-8 and 1830V-8). A hydraulic supply unit (Team Corp. Assembly No. 64401-B) is used to provide the required 2,500-psig hydraulic pressure to operate the bearings. A signal from a pressure switch in the hydraulic supply line is connected into the safety circuit of the Ling shaker to prevent system operation without hydraulic pressure.

2.2.2 Handling Equipment

Test article handling is accomplished by use of the IVA mobile crane in conjunction with special handling and support fixtures provided by the test article manufacturer or AEDC (Fig. 2).

2.3 INSTRUMENTATION

The test instrumentation for both sine and random vibration tests consists of accelerometers placed at designated locations on the FLTSATCOM motor and test fixture (Figs. 3a and b). Accelerometer installation photographs are presented in Figs. 4a through g. The accelerometers were Endevco Model 2228-C tri-axis or Endevco Model

2226-C single axis. The accelerometer output signals were routed to Unholtz-Dickie (Series D-11) charge amplifiers for conditioning and then were recorded on Bell and Howell Model 3700-B magnetic tape recording systems operating at 15 in./sec.

During sine and random testing, the input control accelerometer conditioned signal is measured on a Thermo-Systems, Inc., Model 1060 True RMS voltmeter either directly or through a Ling Model LP-10 low pass filter in series with the voltmeter. Also, selected response accelerometer signals can be displayed in real time on a Honeywell Model 1858 CRT photographic recording visicorder.

During sine vibration testing, the filtered control accelerometer signal is plotted in real time on a Moseley Autograf Model 135 X-Y plotter. Figure 5a is a block diagram of the sine vibration control and data system.

During random vibration testing, the unfiltered signal from the control accelerometer is analyzed with the Spectral Dynamics Model 301-D Real Time Analyzer and Model 309 Ensemble Averager with the acceleration spectral density displayed on a Spectral Dynamics Model 13116 oscilloscope. The acceleration spectral density can also be recorded on the Moseley Autograf Model 135 X-Y plotter. Figure 5b is a block diagram of the random control and data system.

All instrumentation used during the vibration tests was calibrated in accordance with AEDC standard calibration procedures (Table 1).

3.0 PROCEDURE

The FLTSATCOM rocket motor was received at the IVA test unit on January 5, 1977, after undergoing an X-ray inspection at the AEDC Rocket Motor Radiographic Inspection Laboratory. The motor was removed from the transportation fixture, instrumented, and installed in the dynamics test fixture (Figs. 6a and b). Testing of the motor was initiated January 10 and completed January 14, 1977. All testing of the FLTSATCOM motor was conducted with expended initiators installed in the ignition train and the S&A device in the safe position. During the test period, the temperature of the IVA test unit building was maintained in the range from 65 to 75°F except for January 9 and 10 when, due to low outside temperatures, the building temperature ranged from 50 to 60°F. At the conclusion of testing, the motor was placed in the transportation fixture and transported to the AEDC Radiographic Inspection Laboratory for postvibration inspection prior to motor firing in the AEDC Engine Test Facility (ETF) Propulsion Development Test Cell T-3. A summary of the system dynamic test activities and building temperature record is contained in Table 2.

3.1 SINE VIBRATION TEST PROCEDURE

The FLTSATCOM motor was subjected to a sine vibration test in both the thrust and lateral axes. Each of these tests was conducted by sweeping a sinusoidal signal of 1.0-g (0 to peak) magnitude through a frequency range from 5 to 2,000 Hz at a sweep rate of two octaves per minute.

The FLTSATCOM motor was instrumented with accelerometers at the required locations to read responses on the thrust (T), lateral (L), and transverse (TR) axes. The motor was then installed on the test fixture in the orientation for the particular axis to be tested, and the accelerometer cable connections were completed. Accelerometer response and circuit continuity were verified by squeezing each accelerometer in turn and noting a response in the appropriate charge amplifier in the control room. The charge amplifiers were then adjusted to the appropriate levels for the particular accelerometer sensitivity, and the calibration levels were recorded on the magnetic tape.

The sine vibration control equipment was set to operate the shaker at the desired g level, and the frequency was swept through the required range. During each test run the control accelerometer output was plotted in real time on the Moseley Autograf Model 135 X-Y plotter to verify proper input signal. Control accelerometer g level was also displayed on a Thermo Systems Model 1060 True RMS voltmeter. Certain preselected response accelerometer signals were also displayed in real time on the Honeywell Model 1858 CRT visicorder.

After each test run or at the completion of a test axis, accelerometer response data were plotted from the magnetic tape record, and the plots were examined for any abnormalities. Each test run in the thrust or lateral axis was completed in this manner.

3.2 RANDOM VIBRATION TEST PROCEDURE

The FLTSATCOM motor was subjected to random vibration along the thrust and lateral axes with the power spectral density as shown in Fig. 7. Accelerometer cable connections, continuity, charge amplifier settings, and calibrations were accomplished in the same manner for random as for sine vibration testing.

The shaker was operated at a power level 10 db below the full power input level in order to equalize the power spectrum in accordance with the required input spectrum. This low-level equalization was accomplished by analyzing the spectrum with the Real Time Analyzer (analyzer noise bandwidth 7.45 Hz) and adjusting the ASDE-80 random control system equalizer controls to increase or decrease power input at the out-of-tolerance frequency bands. After completion of the low-level equalization, the power level was increased to full power for approximately 15 sec in order to analyze the spectrum at this power level. If the full-level spectrum was not satisfactory, the low-level equalization was repeated until a satisfactory spectrum was achieved. The final equalized run was then made to complete the required 3-min test duration, with the final full-power run time shortened by the duration of the satisfactory full-power equalization runs. The two axes of testing were accomplished in this manner. At the completion of each axis of testing, the accelerometer response data were plotted from the magnetic tape record.

Upon completion of vibration testing, the magnetic tape record of the analog signals was processed through an analog-to-digital converter, and a sample of the equalized run was analyzed using a digital power spectral density analysis program. Bandwidth filters used in this program are as follows: bandwidth 5 Hz from 20 to 100 Hz, bandwidth 10 Hz from 100 to 500 Hz, and bandwidth 25 Hz from 500 to 2,000 Hz. The sample, of approximately 2.4-sec duration, was taken approximately 30 sec prior to completion of the equalized run. A tabulation of the random vibration rms acceleration levels is presented in Table 3.

3.3 VISUAL INSPECTION PROCEDURE

The FLTSATCOM motor was subjected to several detailed visual inspections during the test period. These inspections were performed upon receipt of the motor, following each test, during change of the motor from one axis to another, and prior to packaging the motor for transfer to the AEDC X-ray laboratory. No abnormalities attributable to the imposition of the dynamic environment were noted during any of these inspections.

The test fixtures were also visually inspected, and bolt torques were spot checked periodically. No abnormalities were noted, and no bolts were found to be below required torque values.

4.0 RESULTS AND DISCUSSION

4.1 LATERAL AXIS SINE VIBRATION

The lateral axis sine test was conducted on January 11, 1977. The test consisted of sweeping a sinusoidal signal of 1.0-g (0 to peak) magnitude through a frequency range from 5 to 2,000 Hz at a rate of two octaves per minute. The X-Y plots of the filtered signal from all response accelerometers and the control accelerometer are shown in Figs. 8a through p. All responses were similar to those measured on the previous qualification motor.

4.2 LATERAL AXIS RANDOM VIBRATION

The lateral axis random vibration testing was conducted in two full-level runs at an rms g level of approximately 9.25 g's. The first run was for a duration of 15 sec and was to verify the acceleration spectral density after equalization at a lower level. The second run was for a duration of 2 min and 45 sec to complete the required 3 min of total run time. During each test run, the acceleration spectral density was monitored on the Real Time Analyzer. Figure 9 contains the random vibration run time record, including all equalization time at -10 db and the real time analyzer plots of the -10 db and full power equalized spectrum. A digital analysis of a period approximately 30 sec prior to the end of the equalized run was made for all accelerometers upon completion of testing, and the acceleration spectral density plots of this analysis are shown in Figs. 10a through p.

4.3 THRUST AXIS SINE VIBRATION

Transfer of the FLTSATCOM motor to the thrust axis test fixture was accomplished on January 12, 1977, and the sine vibration test was conducted. The test consisted of sweeping a sinusoidal signal of 1.0-g magnitude (0 to peak) through a frequency range from 5 to 2,000 Hz at a rate of two octaves per minute. The X-Y plots of the filtered signal from all response accelerometers and the control accelerometer are shown in Figs. 11a through p.

4.4 THRUST AXIS RANDOM VIBRATION

The motor was subjected to random vibration for 3 min total duration at an rms g level of approximately 9.25 g's. Two full-level runs of 15 sec duration were made after equalization at a lower level. The final run was for a duration of 2 min and 45 sec to complete the required 3 min of total test time with the satisfactory spectrum. The acceleration spectral density was monitored during each run on the Real Time Analyzer (Fig. 12). The accelerometer data were reduced with the digital analysis program, and the acceleration spectral density plots are shown in Figs. 13a through p.

4.5 VISUAL INSPECTION

The motor was subjected to a detailed visual inspection prior to the start of testing, after each test, and prior to transfer to the AEDC X-ray laboratory. No abnormal conditions were found during any of these inspections.

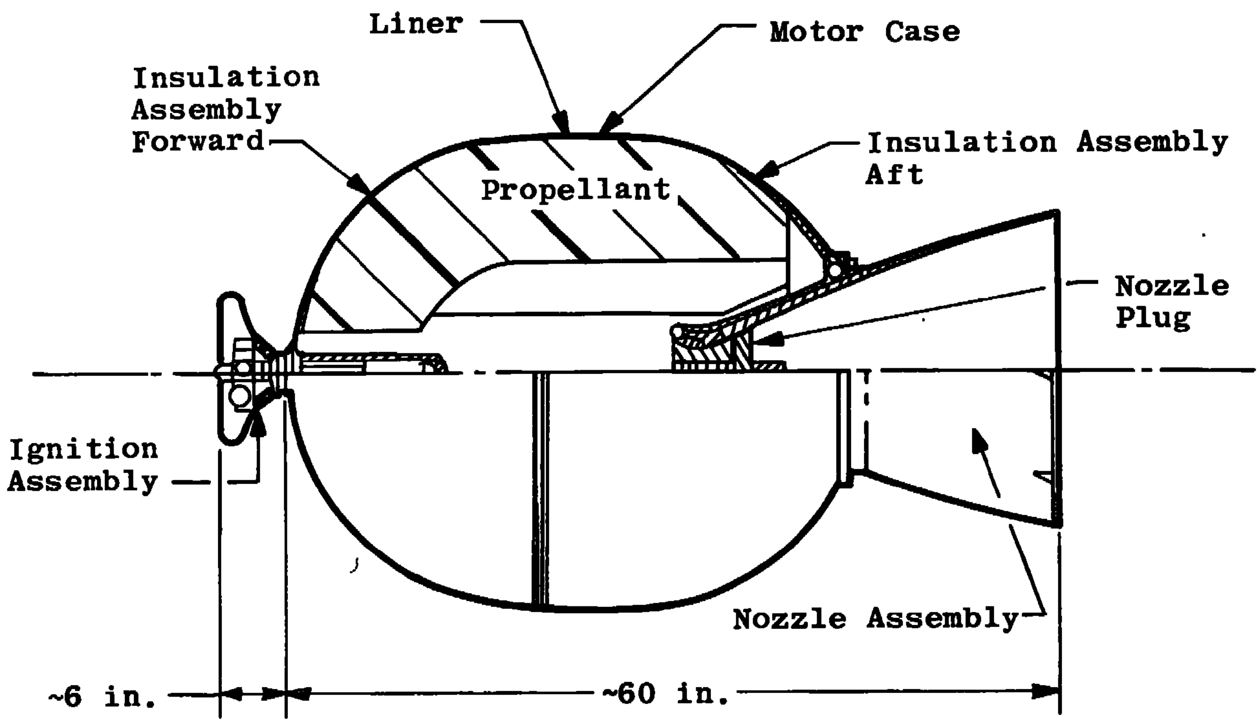
5.0 SUMMARY OF RESULTS

The FLTSATCOM Apogee Kick Motor (S/N 19006 Q-2) was tested in the AEDC IVA test unit for motor qualification purposes. The motor was subjected to a sinusoidal sweep of 1.0 g's (0 to peak) from 5 to 2,000 Hz at a rate of two octaves per minute and one random vibration test at approximately 9.25-g rms for 3 min duration in both the lateral and thrust axes. The FLTSATCOM motor was visually inspected after each test, and no abnormalities were found.

REFERENCES

1. Alt, R. E. and Nelson, R. M. "Vibration Testing of the Thiokol Chemical Corporation FLTSATCOM Apogee Kick Motor D-2 (System S/N 19002 D-2)." AEDC-TR-74-46 (AD919274L), May 1974.

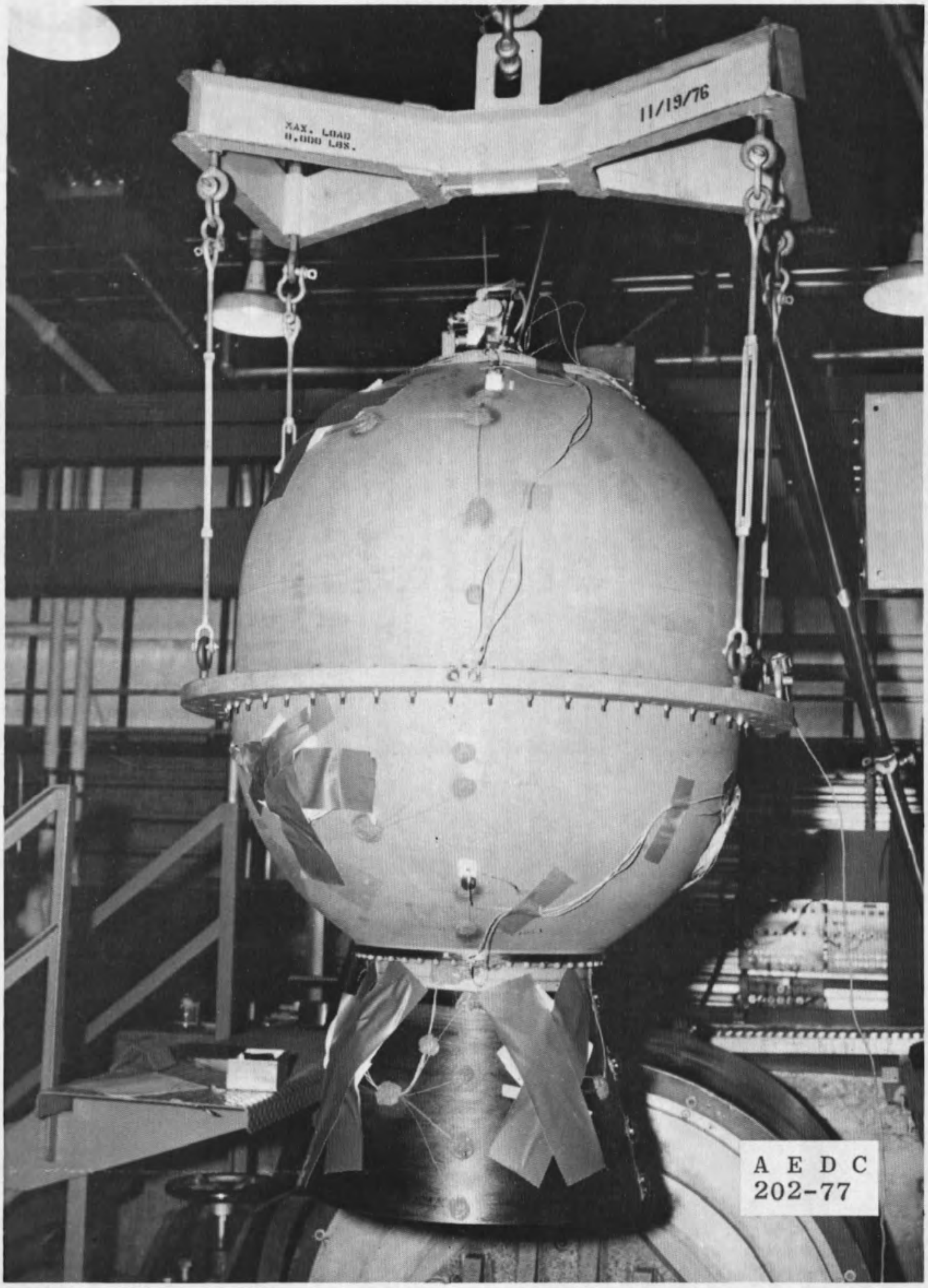
2. Nelson, R. M. "Vibration Testing of Thiokol Chemical Corporation FLTSATCOM Apogee Kick Motor D-2 (System S/N 19003 Q-1)." AEDC-TR-74-89 (AD922001L), September 1974.



Nominal FLTSATCOM Motor Weight Breakdown, lb

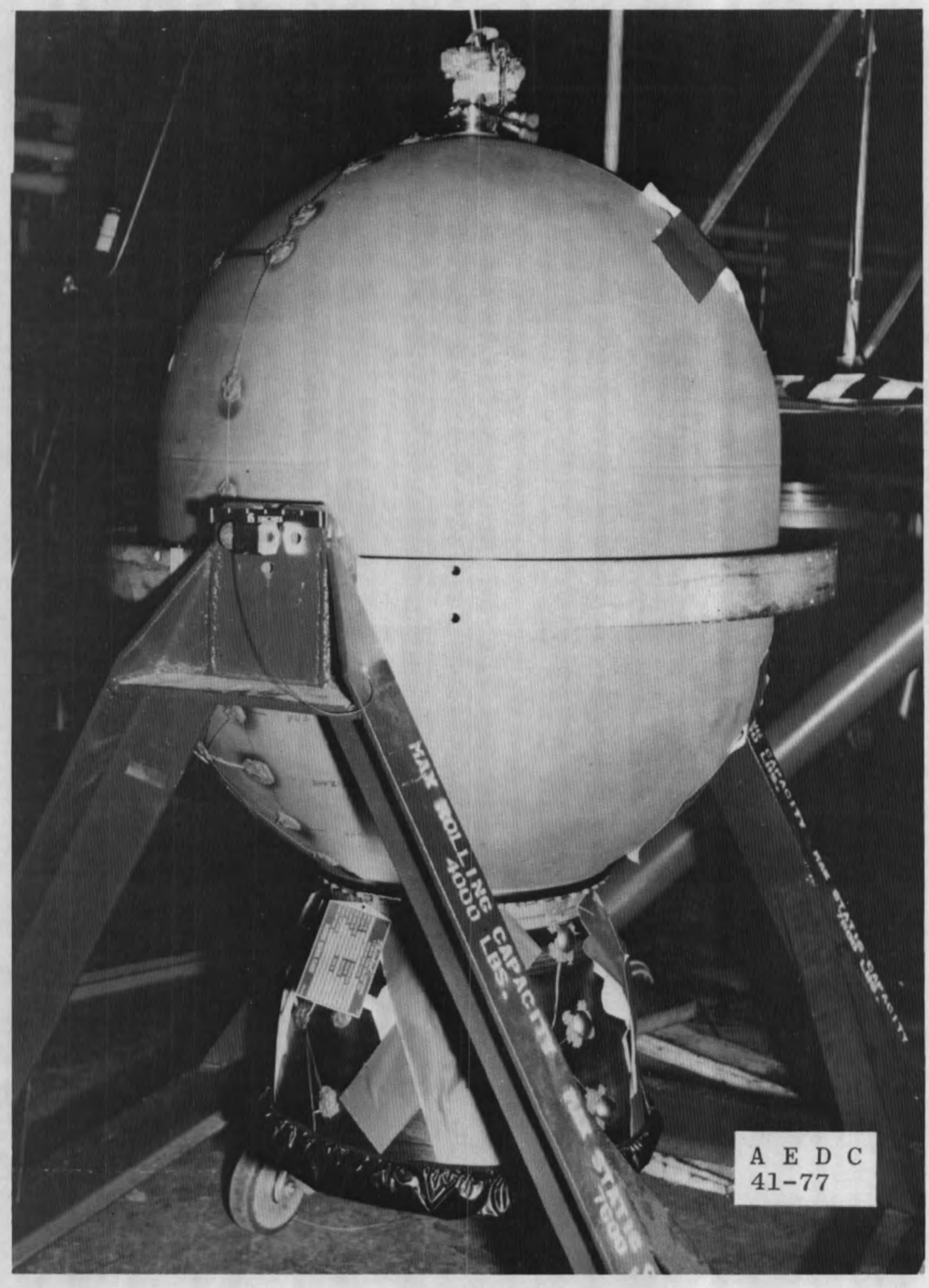
Empty Motor	150
Propellant TP-H-3062	1860
Fully Loaded Motor	2010

Figure 1. FLTSATCOM apogee kick motor.

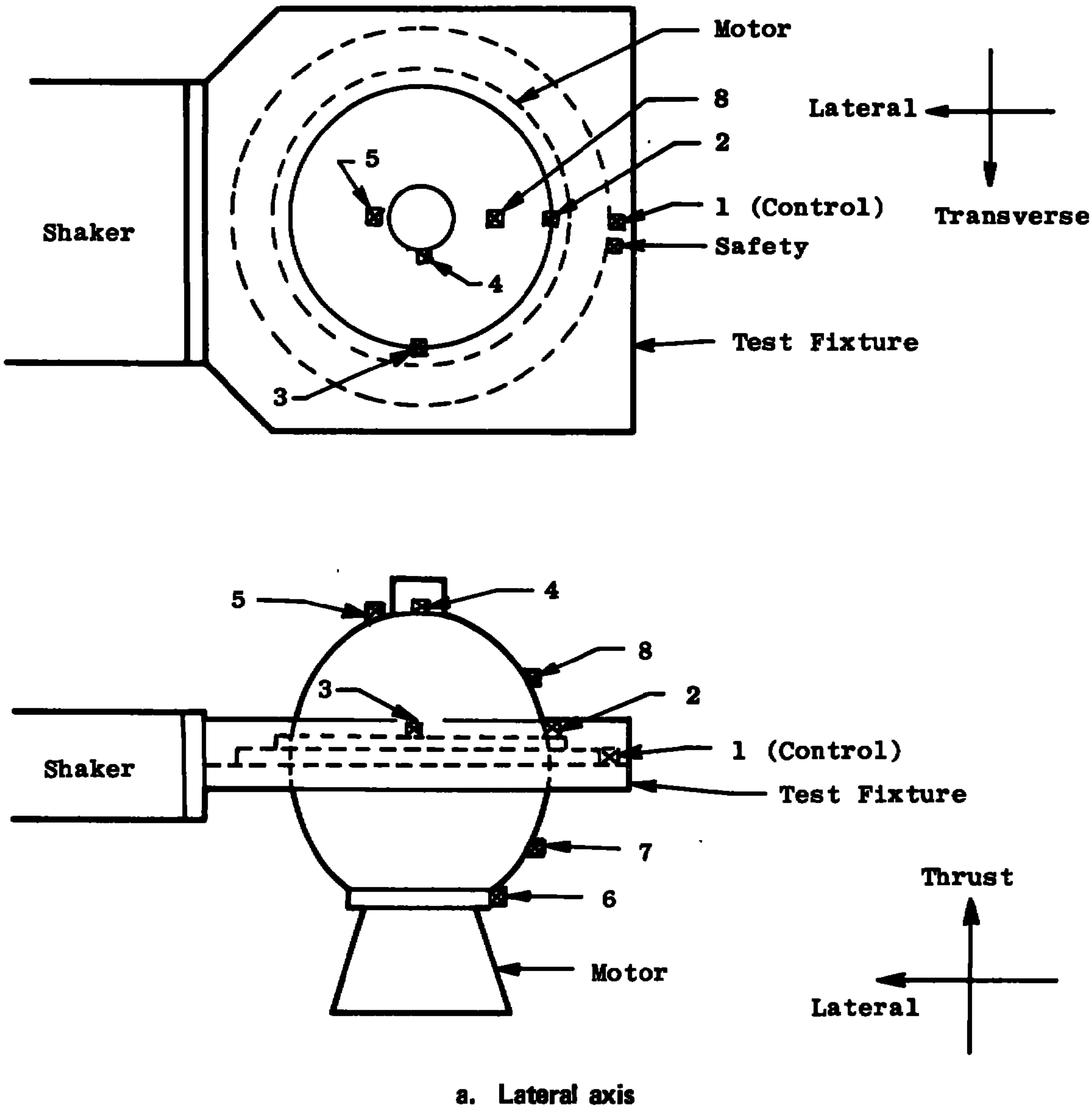


a. Hoisting beam and dynamics ring
Figure 2. FLTSATCOM handling equipment.

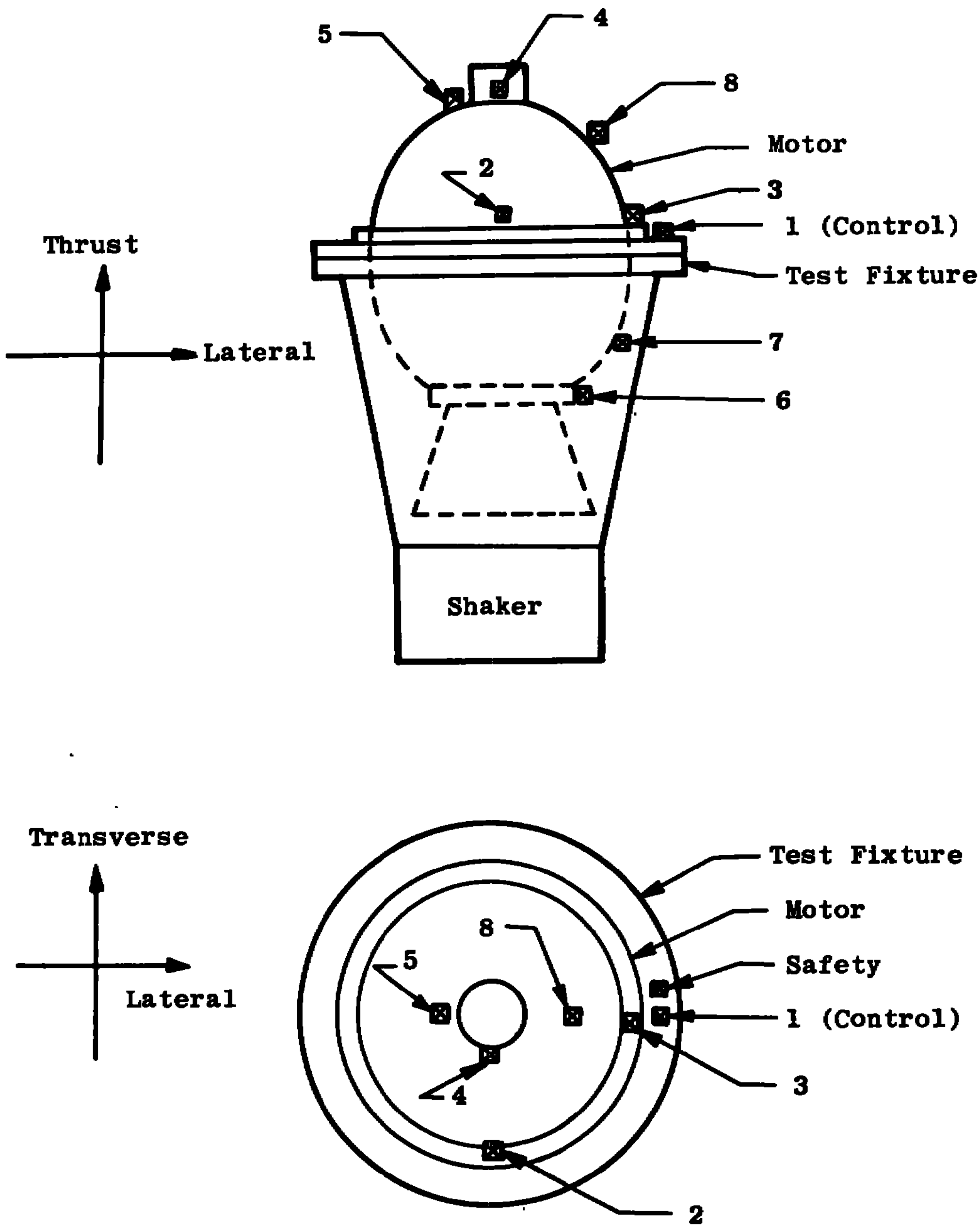
b. Support stand
Figure 2. Continued.



c. Turnover stand
Figure 2. Concluded.



a. Lateral axis
Figure 3. Accelerometer locations and designations.



b. Thrust axis
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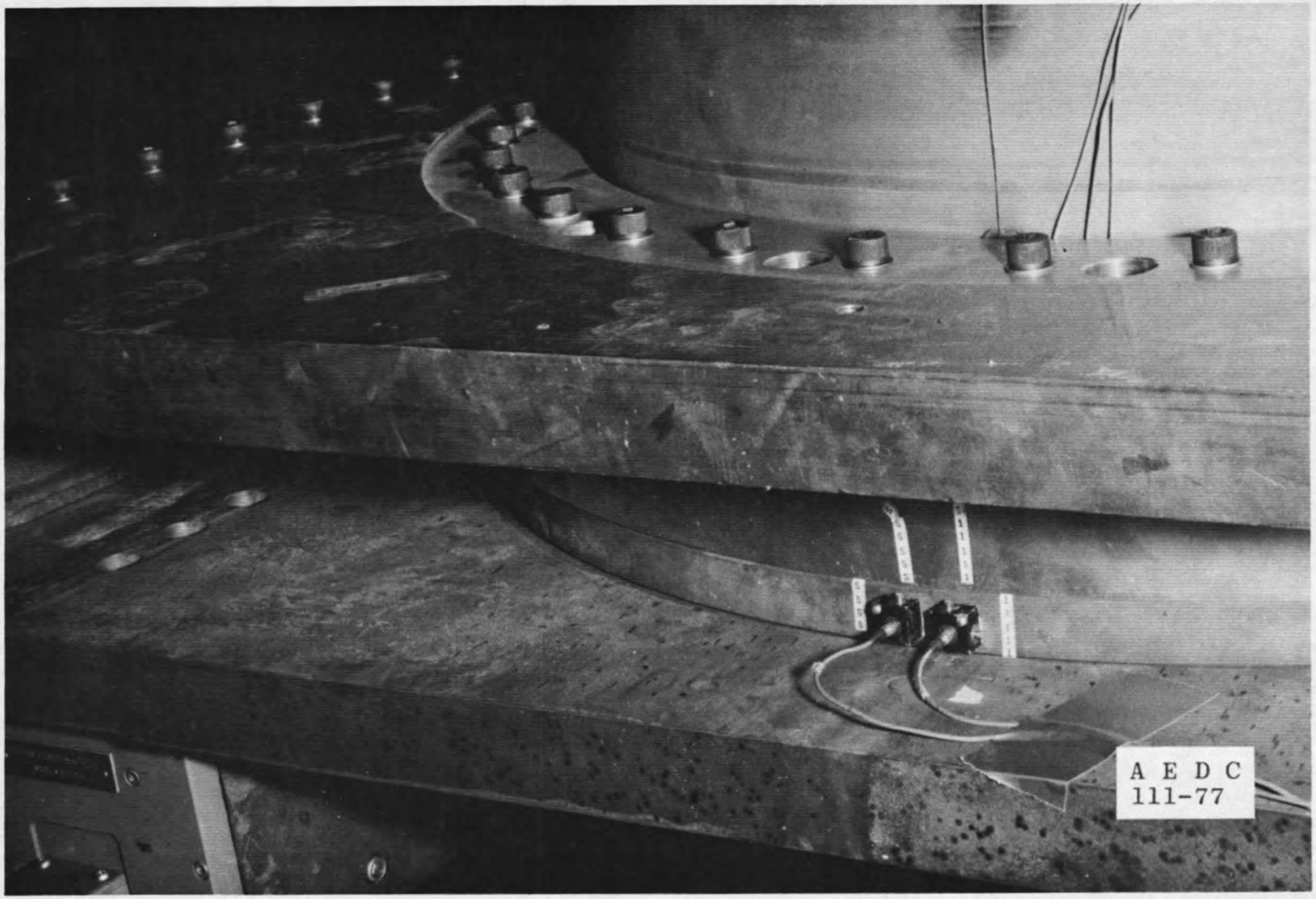
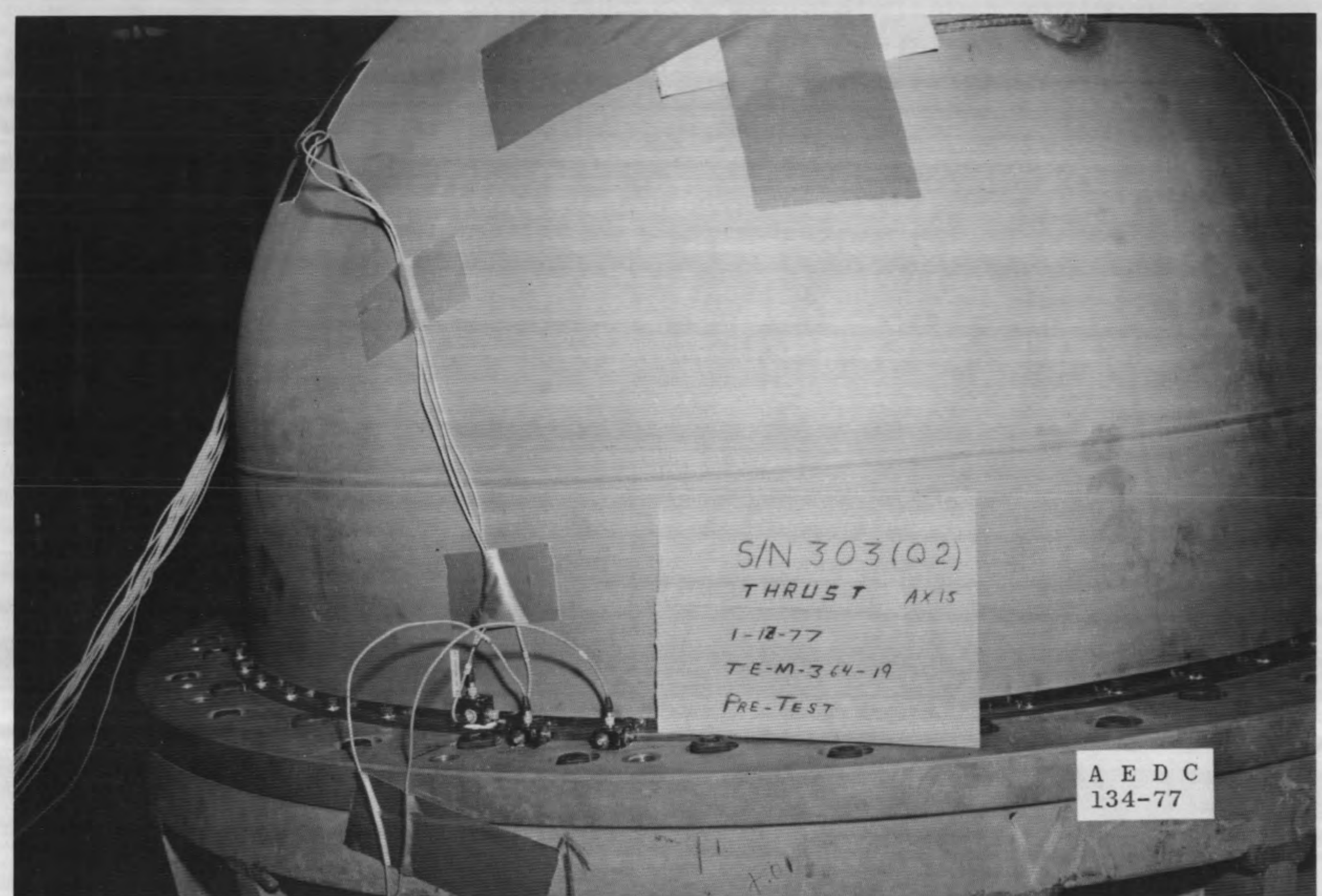
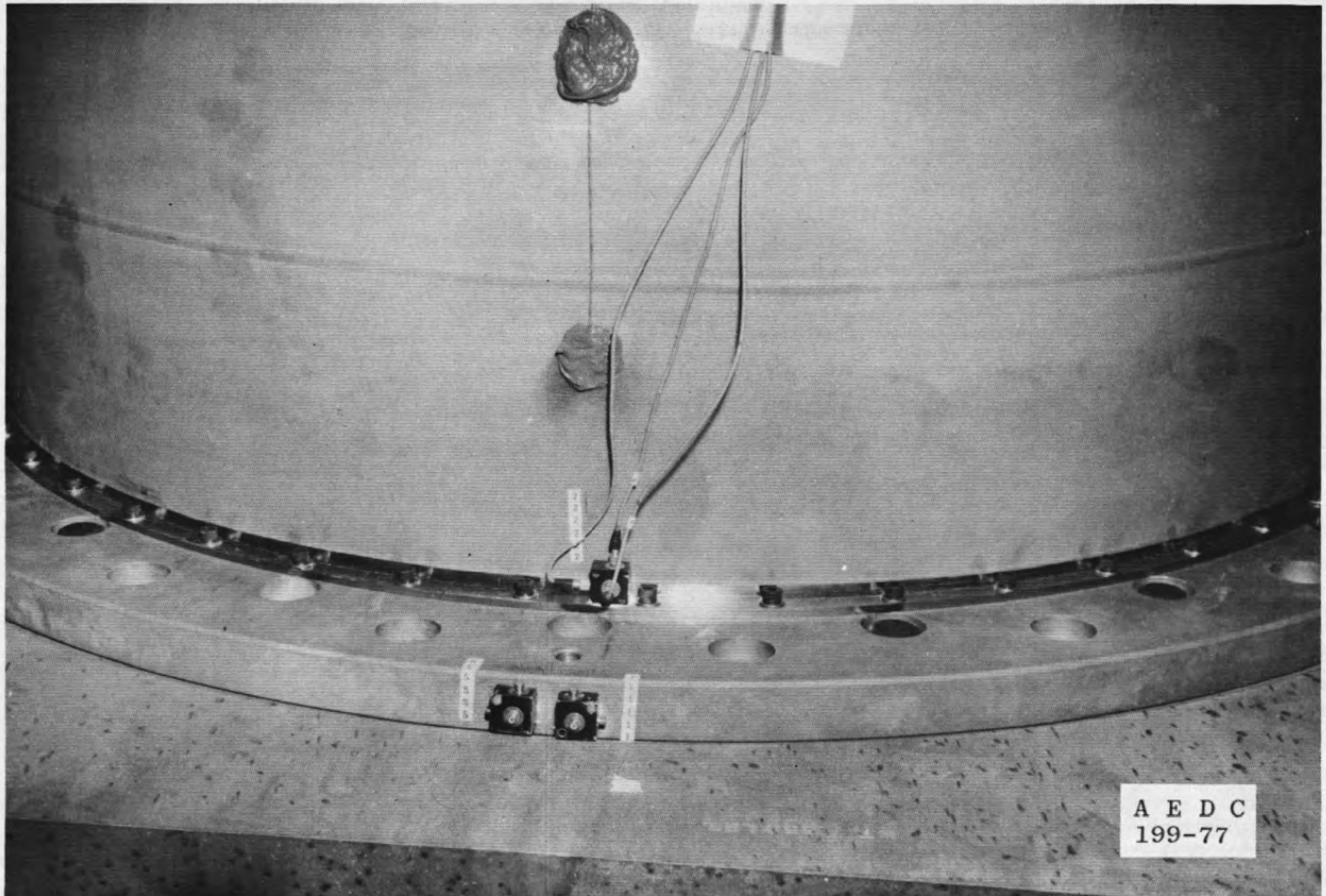


a. Control accelerometer (1) and safety accelerometer (S): lateral axis
Figure 4. Accelerometer installation.

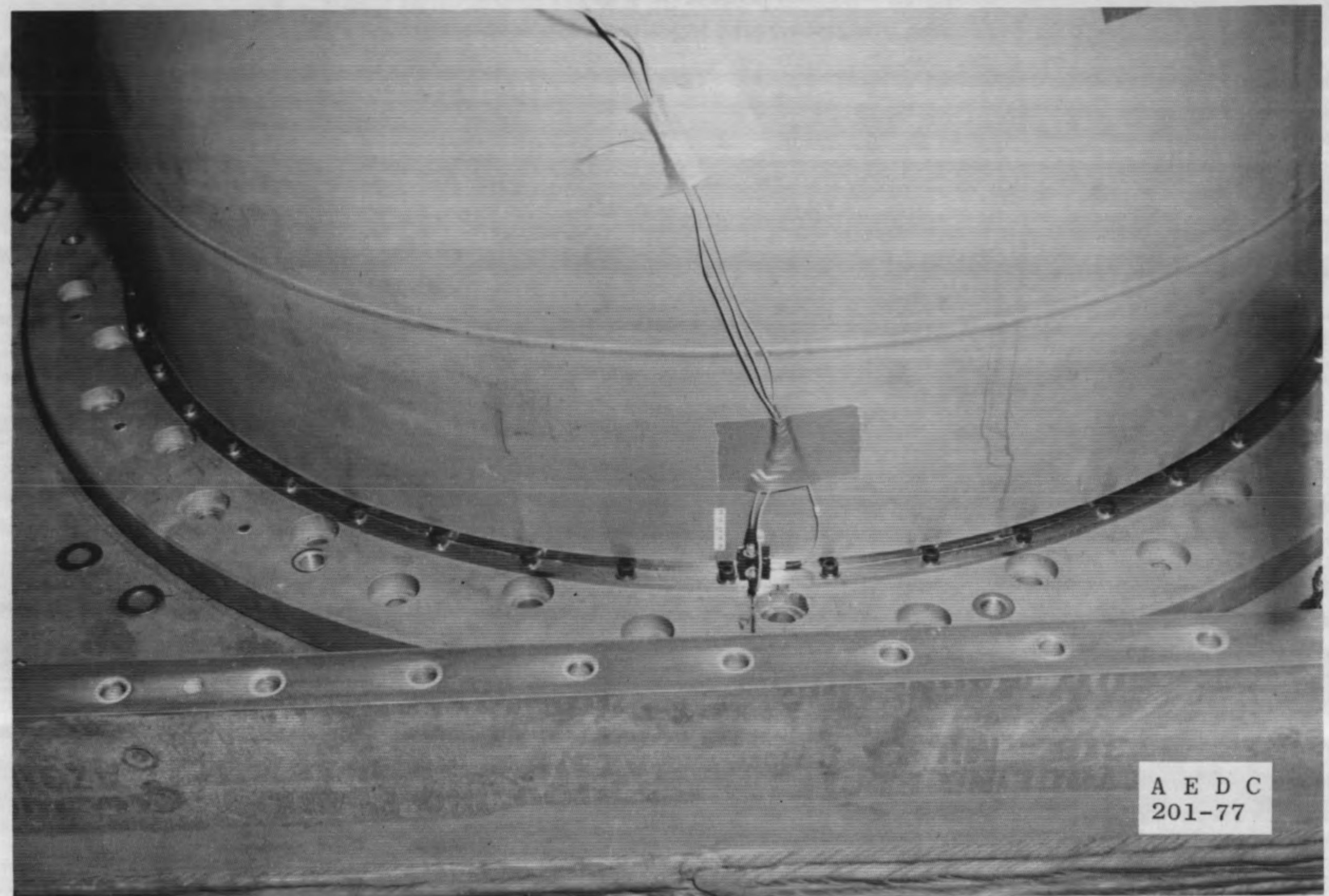


b. Control accelerometer (1), safety accelerometer (S), and response accelerometer (3): thrust axis

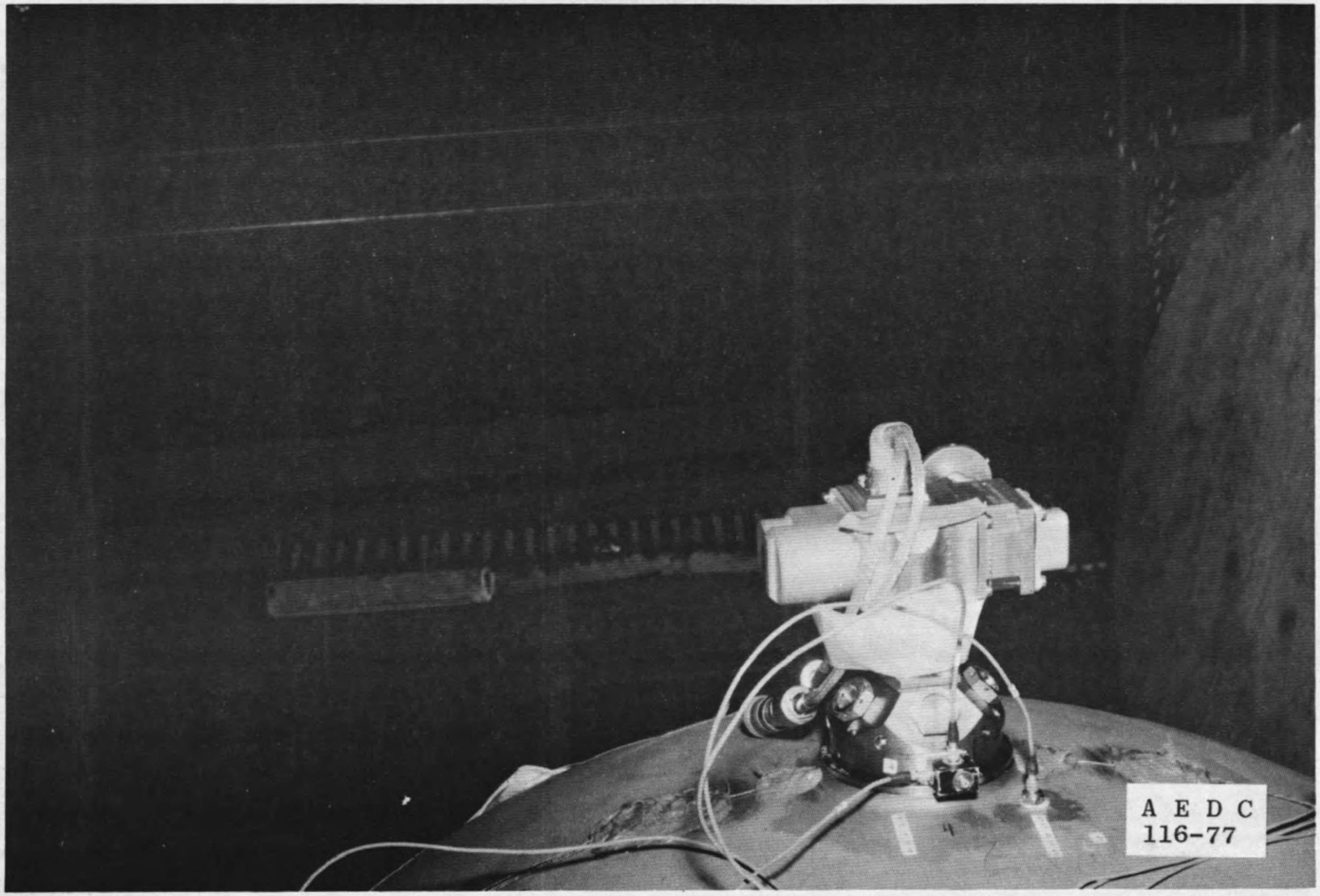
Figure 4. Continued.



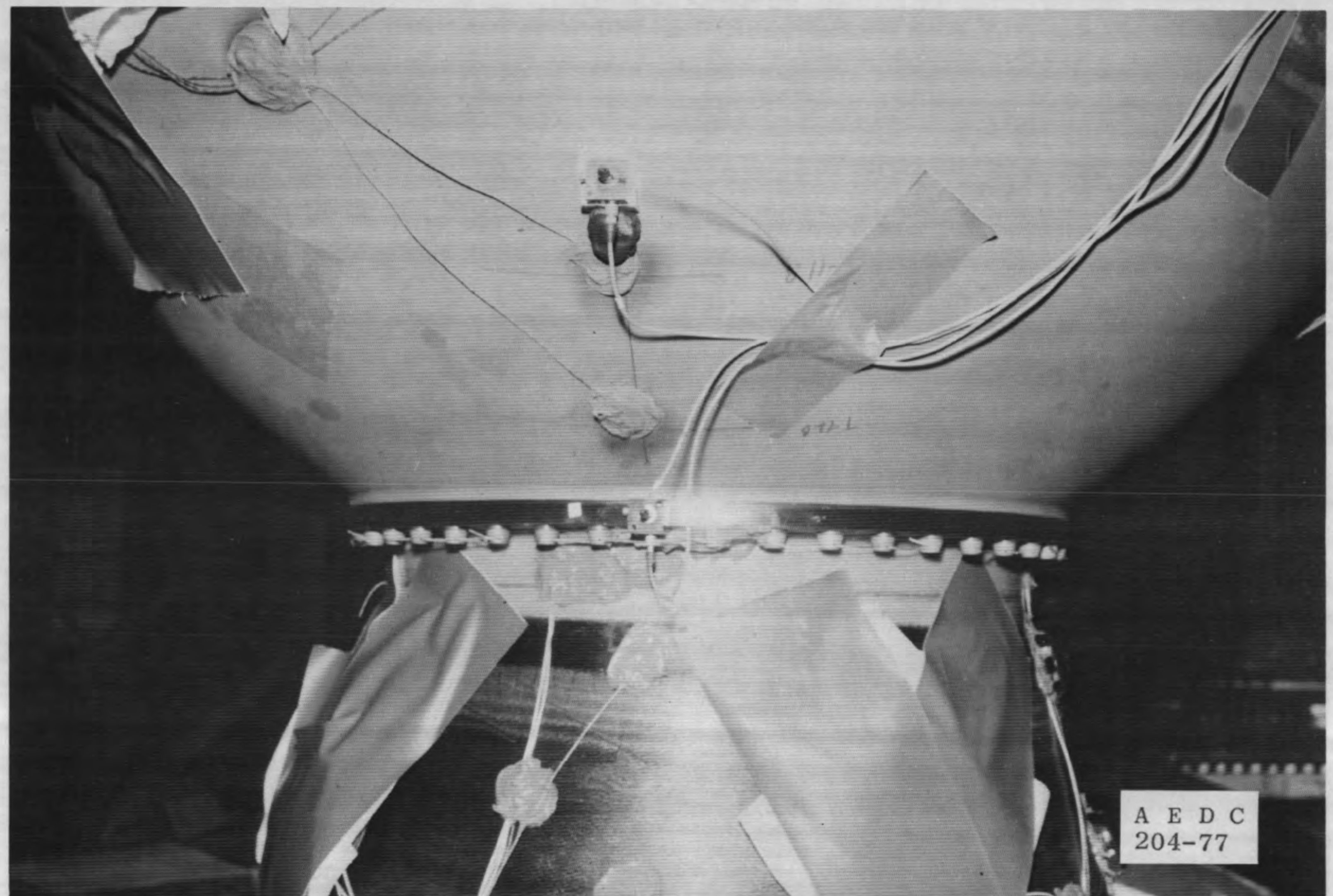
c. Response accelerometer (2): lateral and thrust axes
Figure 4. Continued.



d. Response accelerometer (3): lateral and thrust axes
Figure 4. Continued.

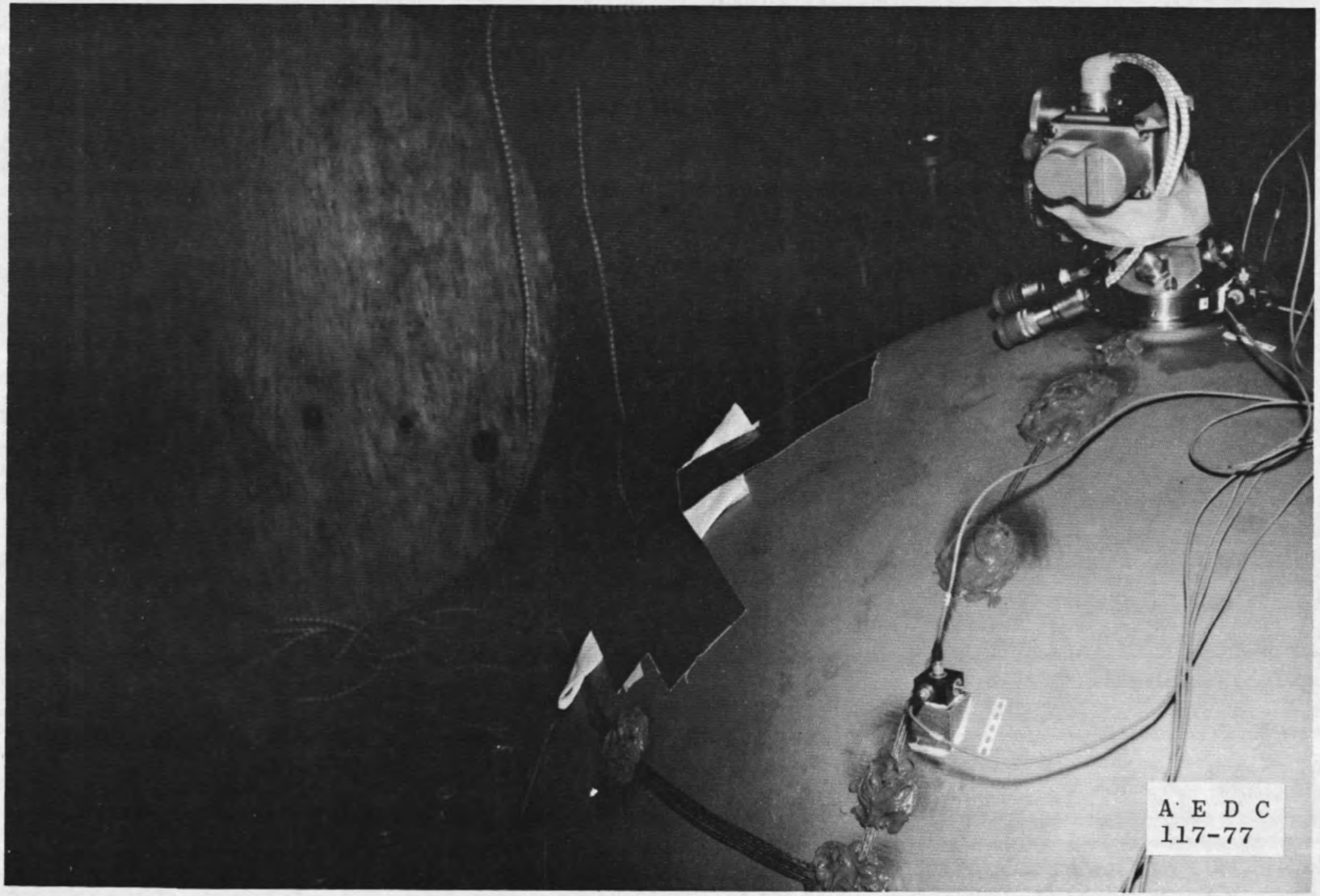


e. Response accelerometers (4) and (5): lateral and thrust axes
Figure 4. Continued.

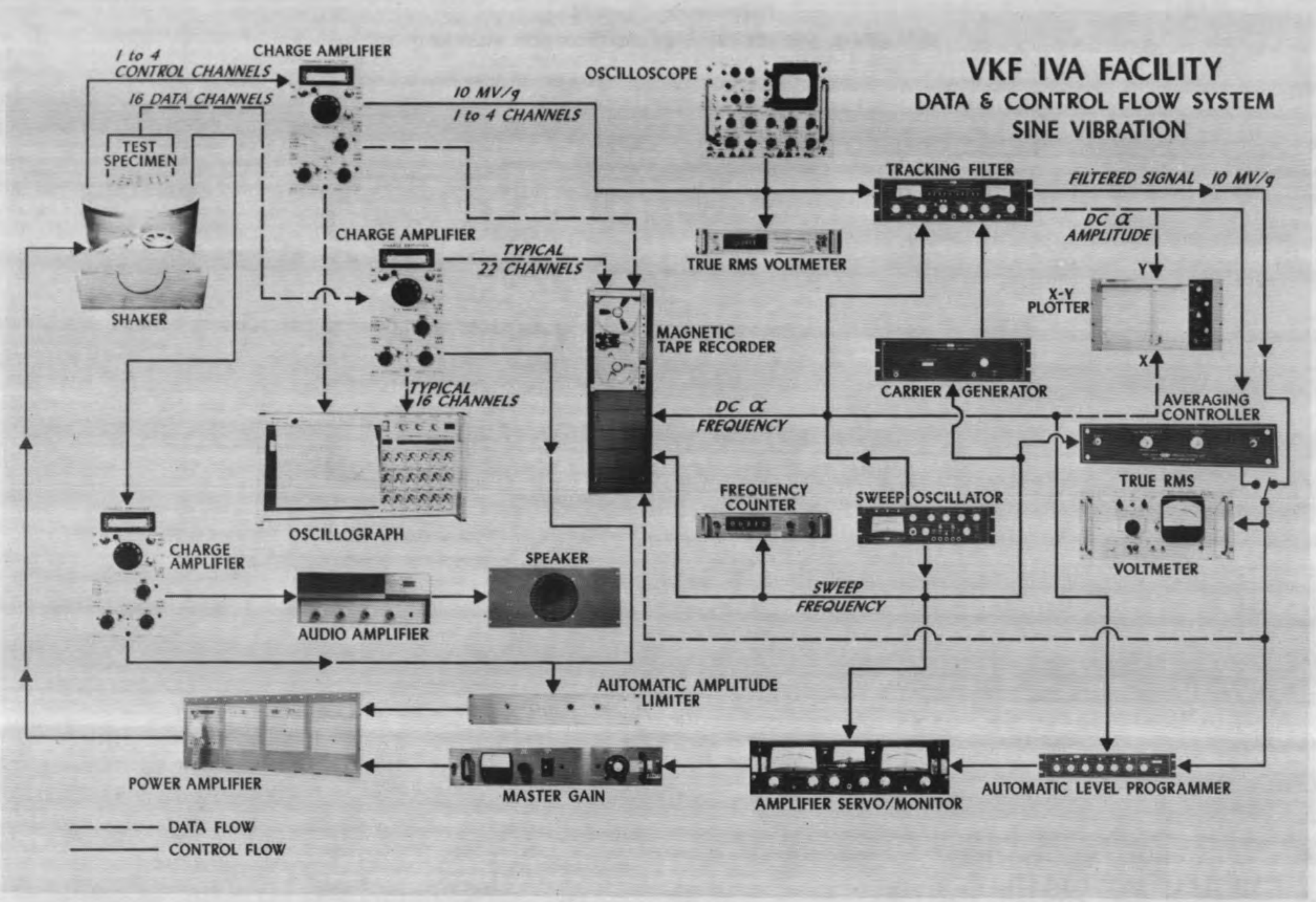


f. Response accelerometers (6) and (7): lateral and thrust axes

Figure 4. Continued.

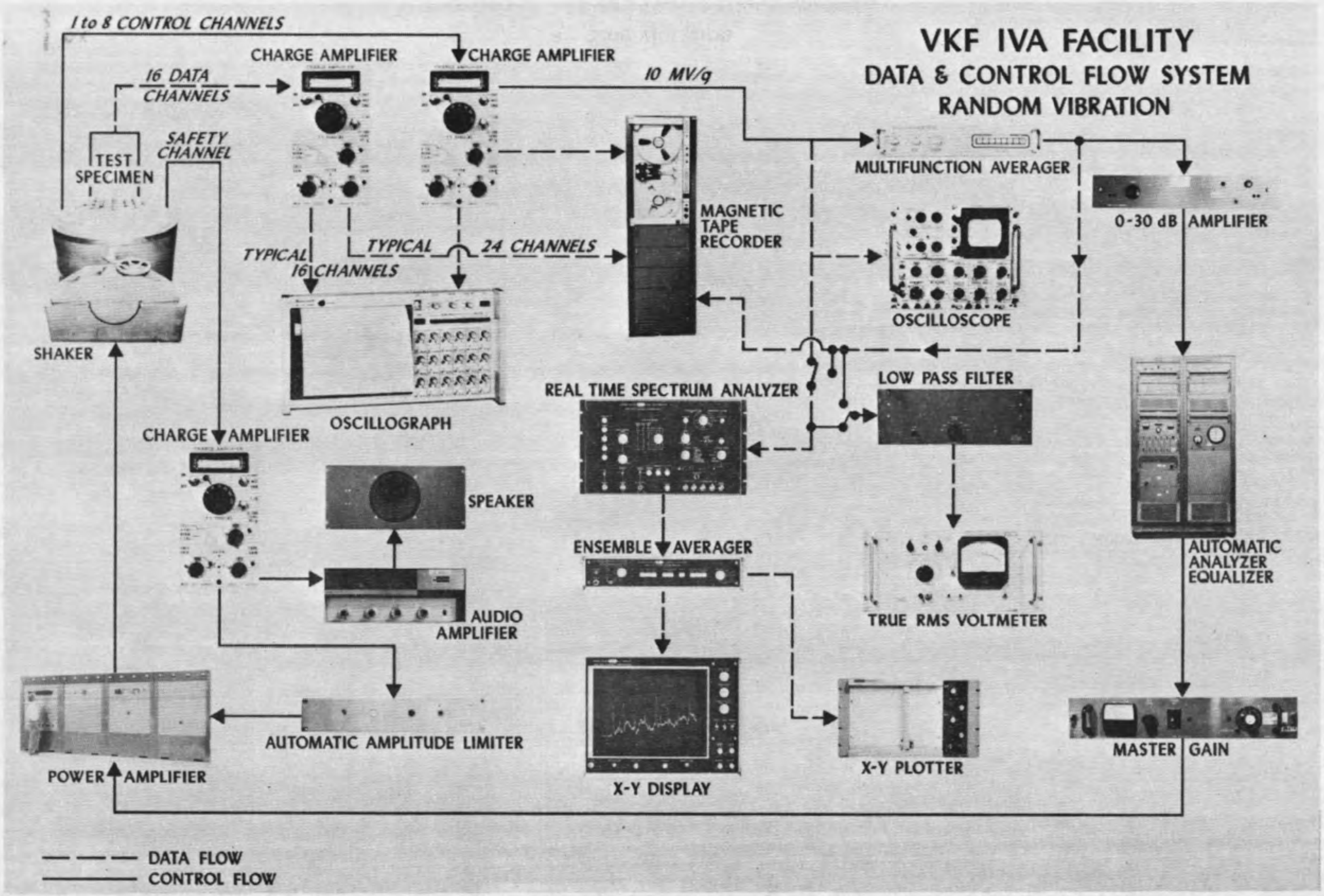


g. Response acclerometer (8): lateral and thrust axes
Figure 4. Concluded.

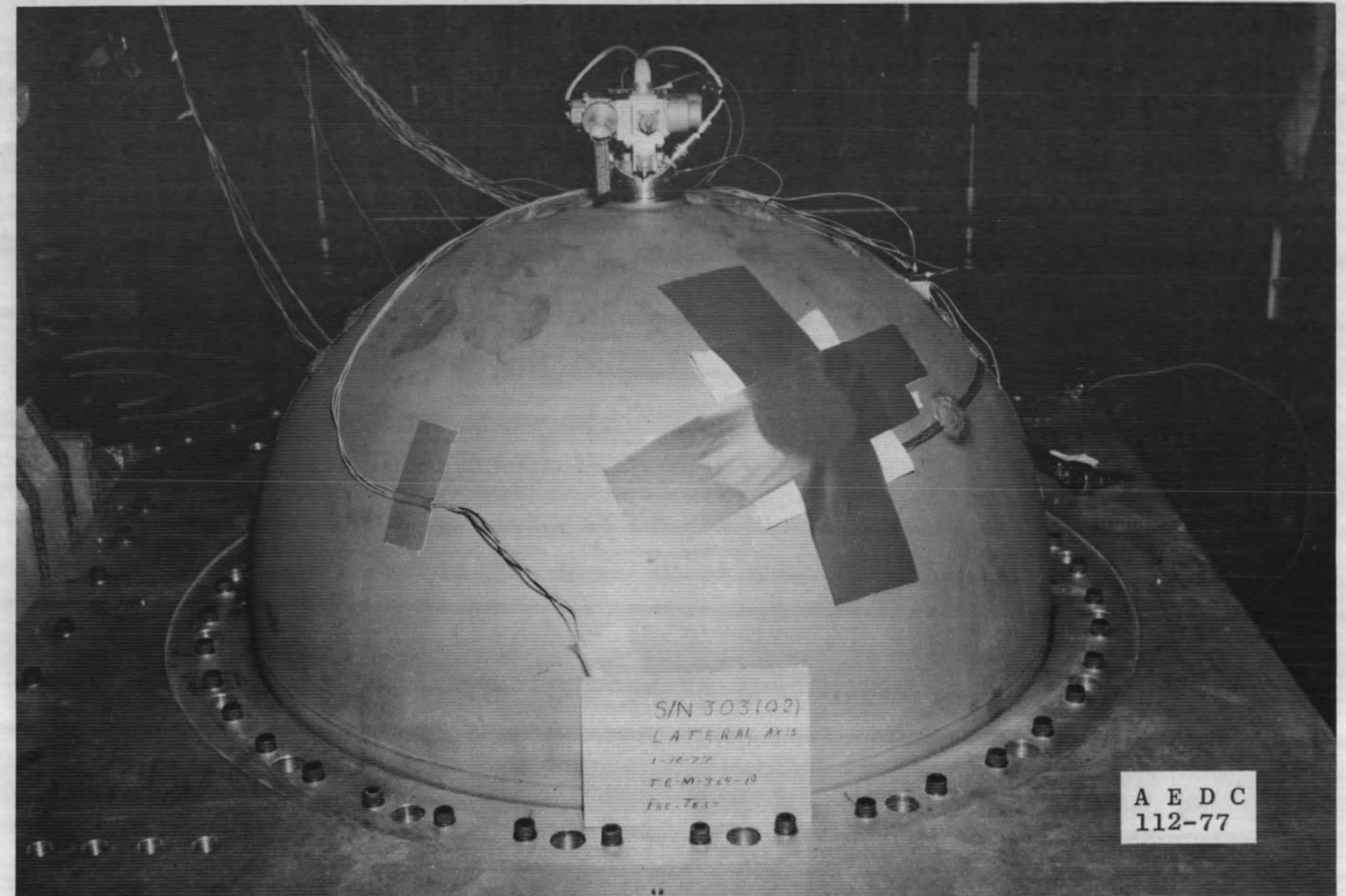


a. Sine vibration

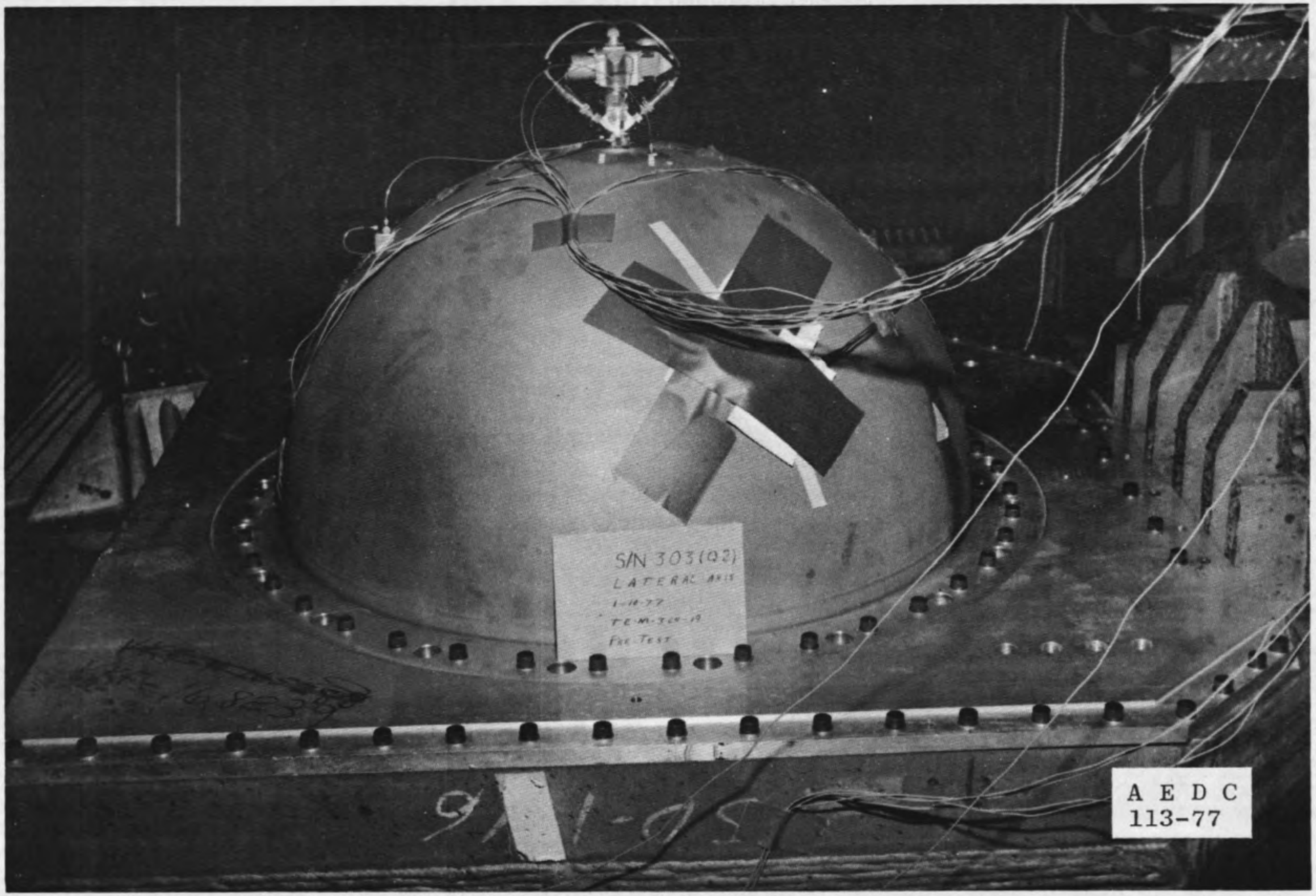
Figure 5. Data and control flow system.



b. Random vibration
Figure 5. Concluded.



a. Lateral axis
Figure 6. FLTSATCOM test installation.



a. Concluded
Figure 6. Continued.

b. Thrust axis
Figure 6. Continued.

b. Concluded
Figure 6. Concluded.

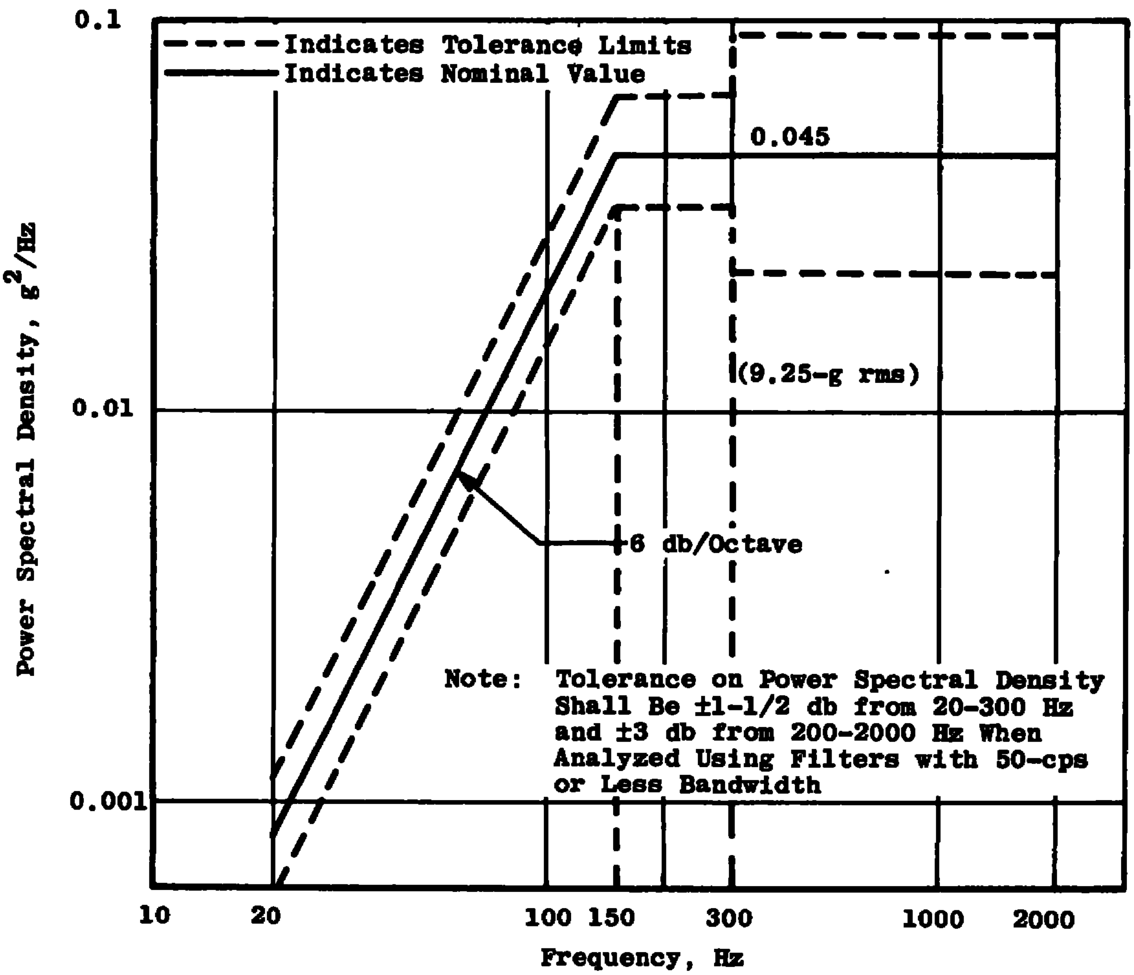
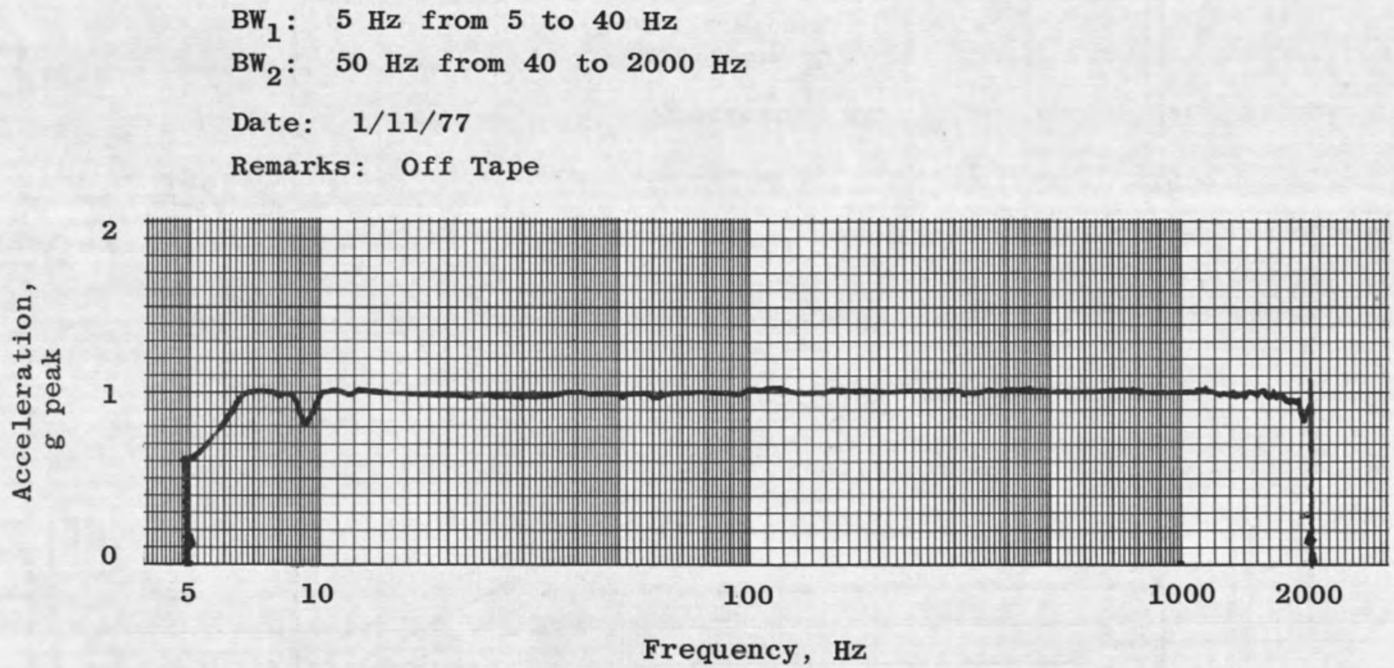
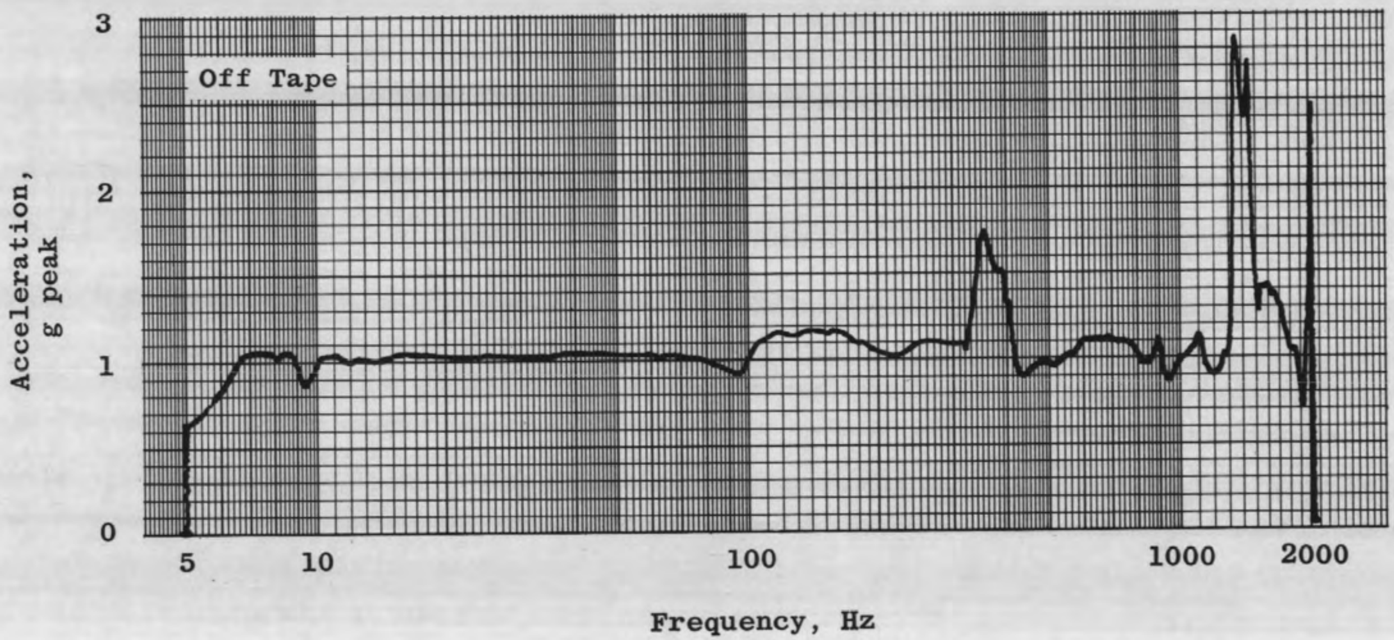


Figure 7. Random vibration test spectrum.

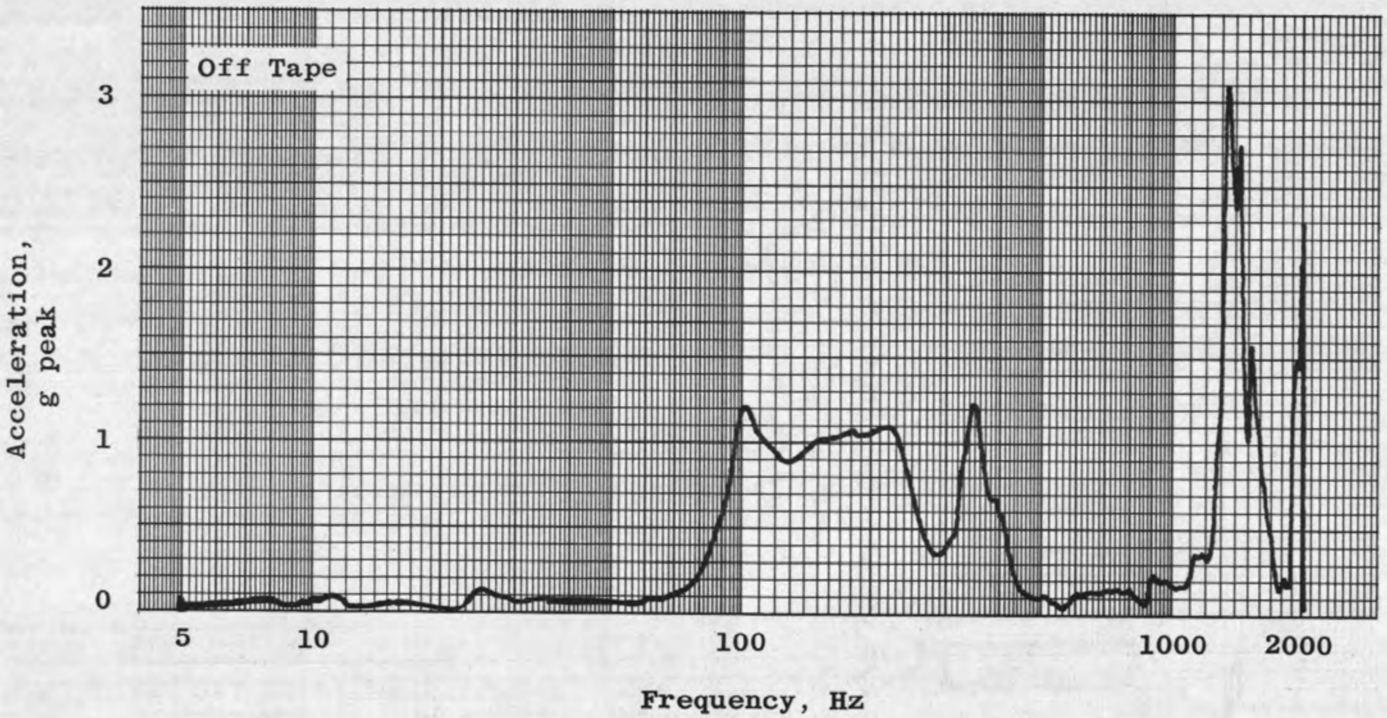


a. Accelerometer 1L (control)

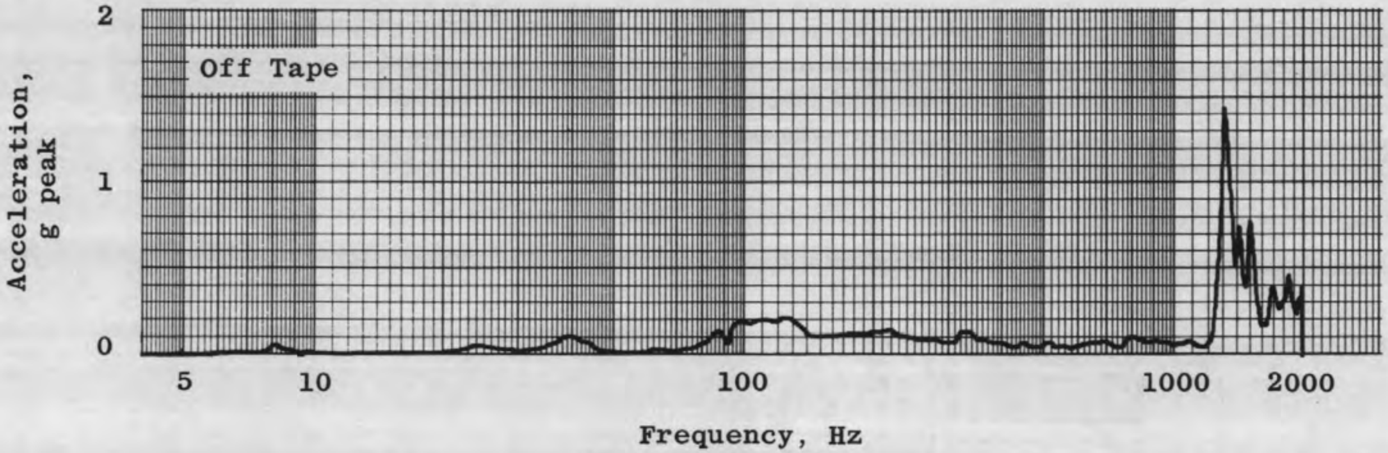
Figure 8. 1-g sine vibration: lateral axis.



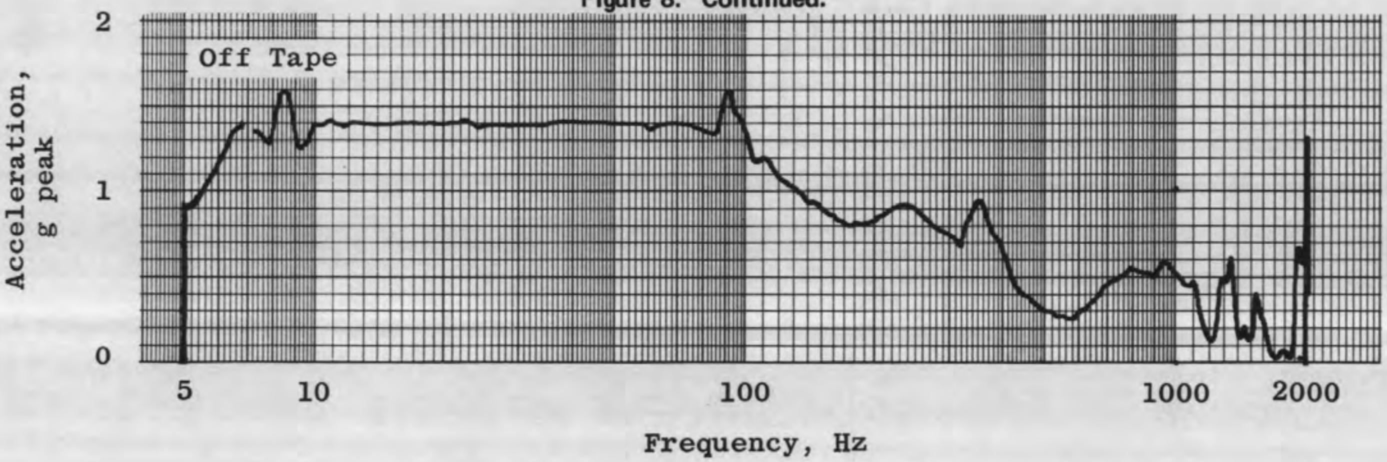
b. Accelerometer 2L
Figure 8. Continued.



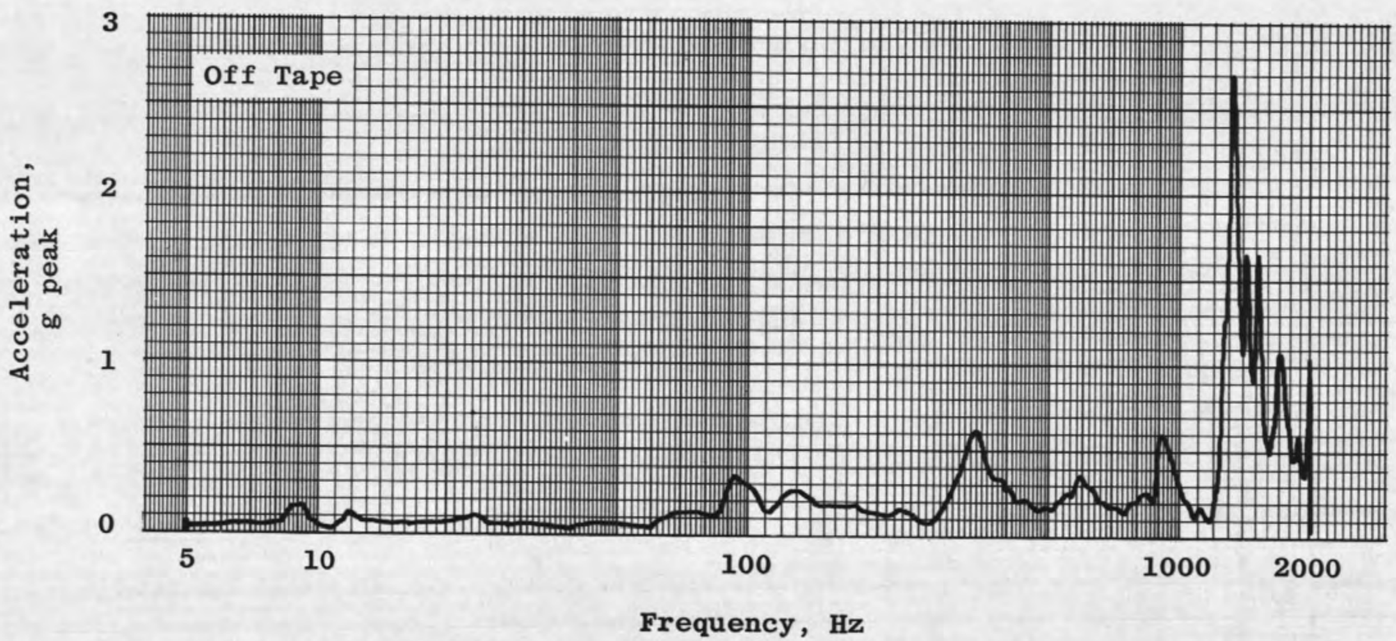
c. Accelerometer 2T
Figure 8. Continued.



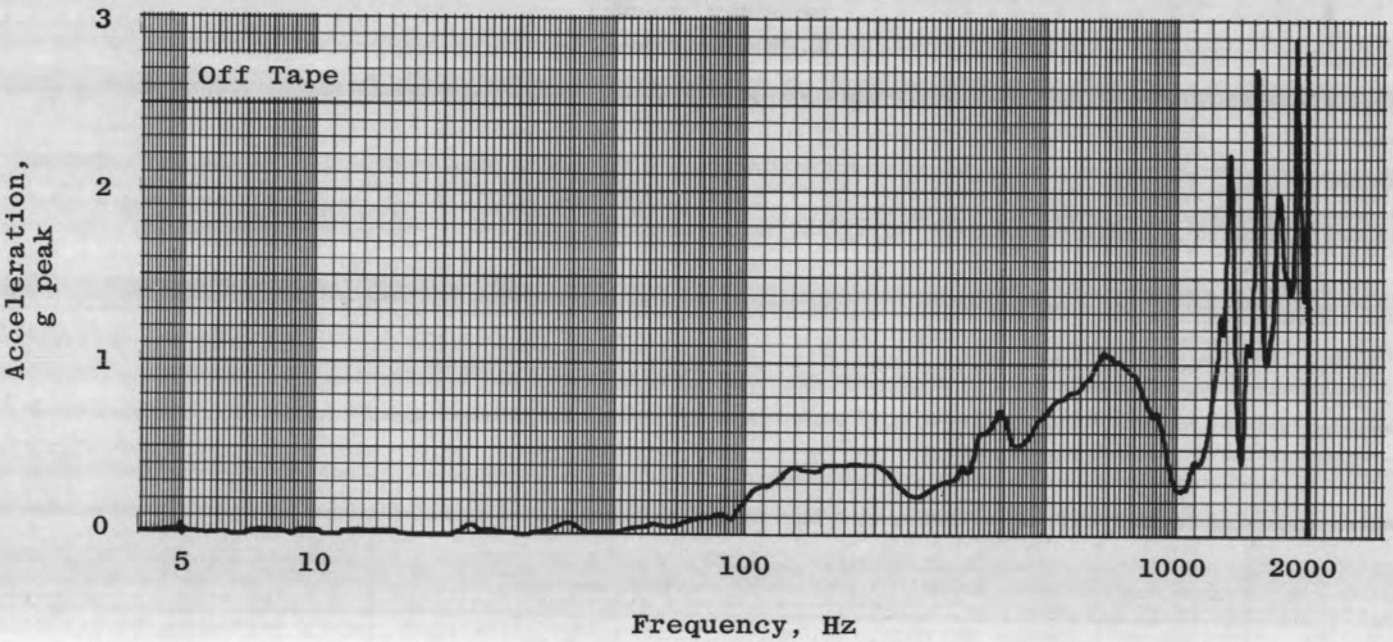
d. Accelerometer 2TR
Figure 8. Continued.



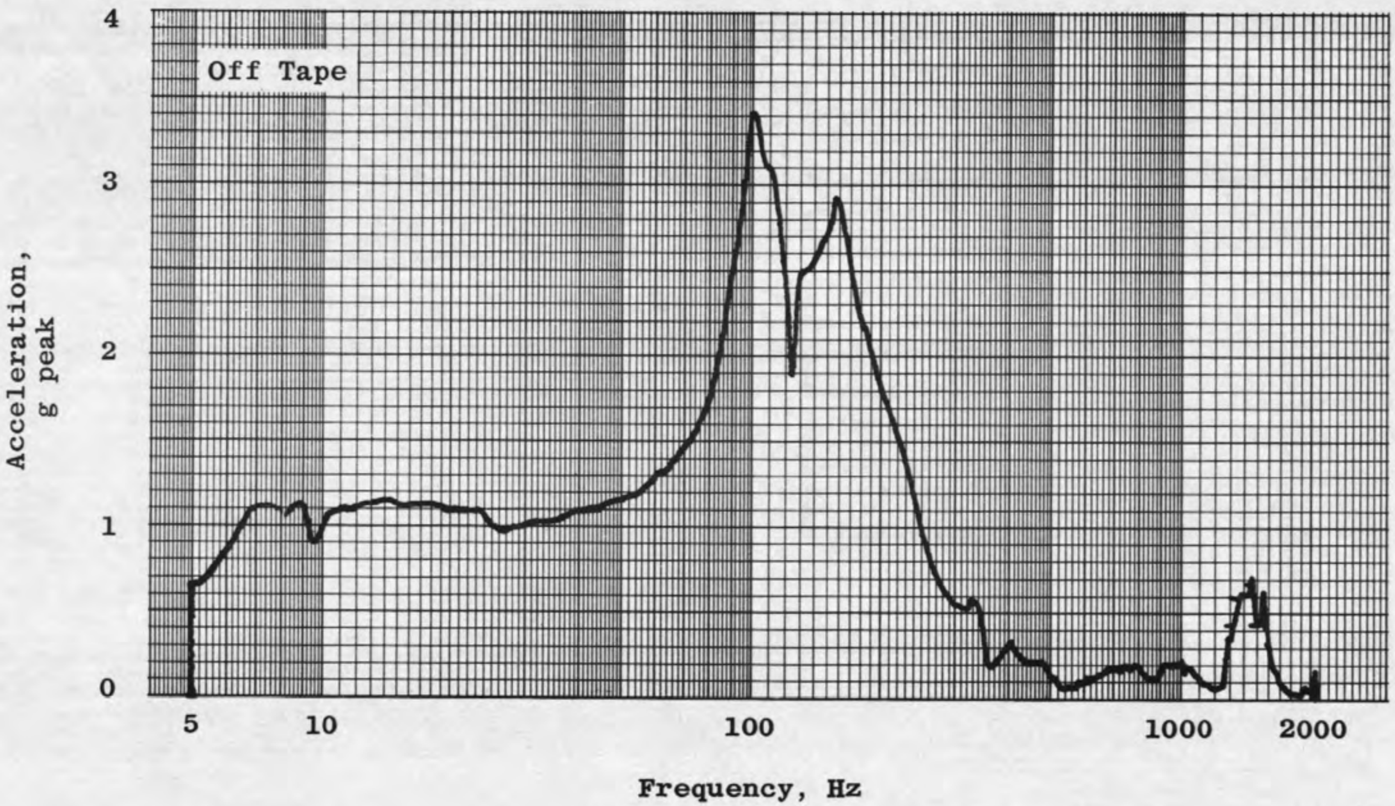
e. Accelerometer 3L
Figure 8. Continued.



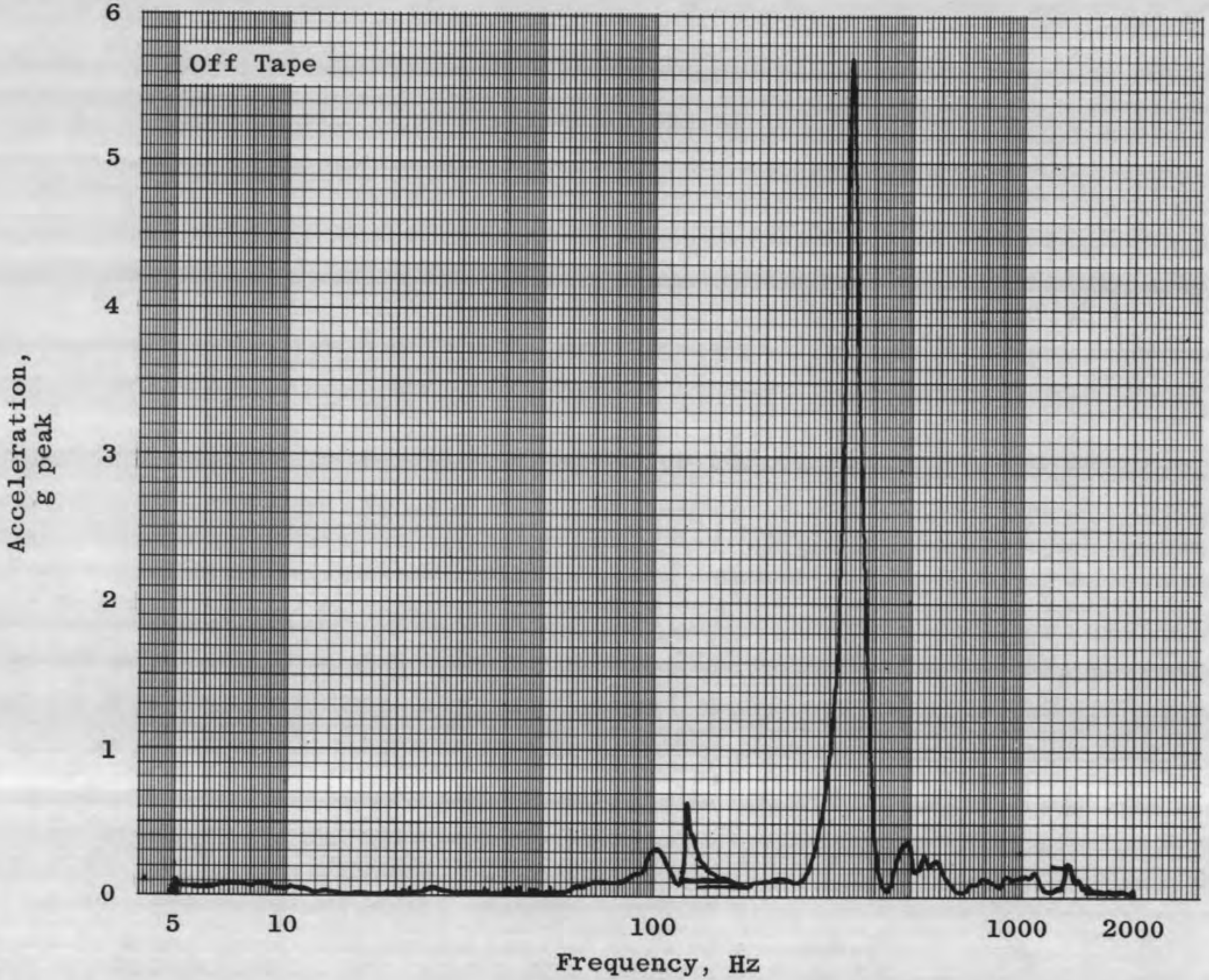
f. Accelerometer 3T
Figure 8. Continued.



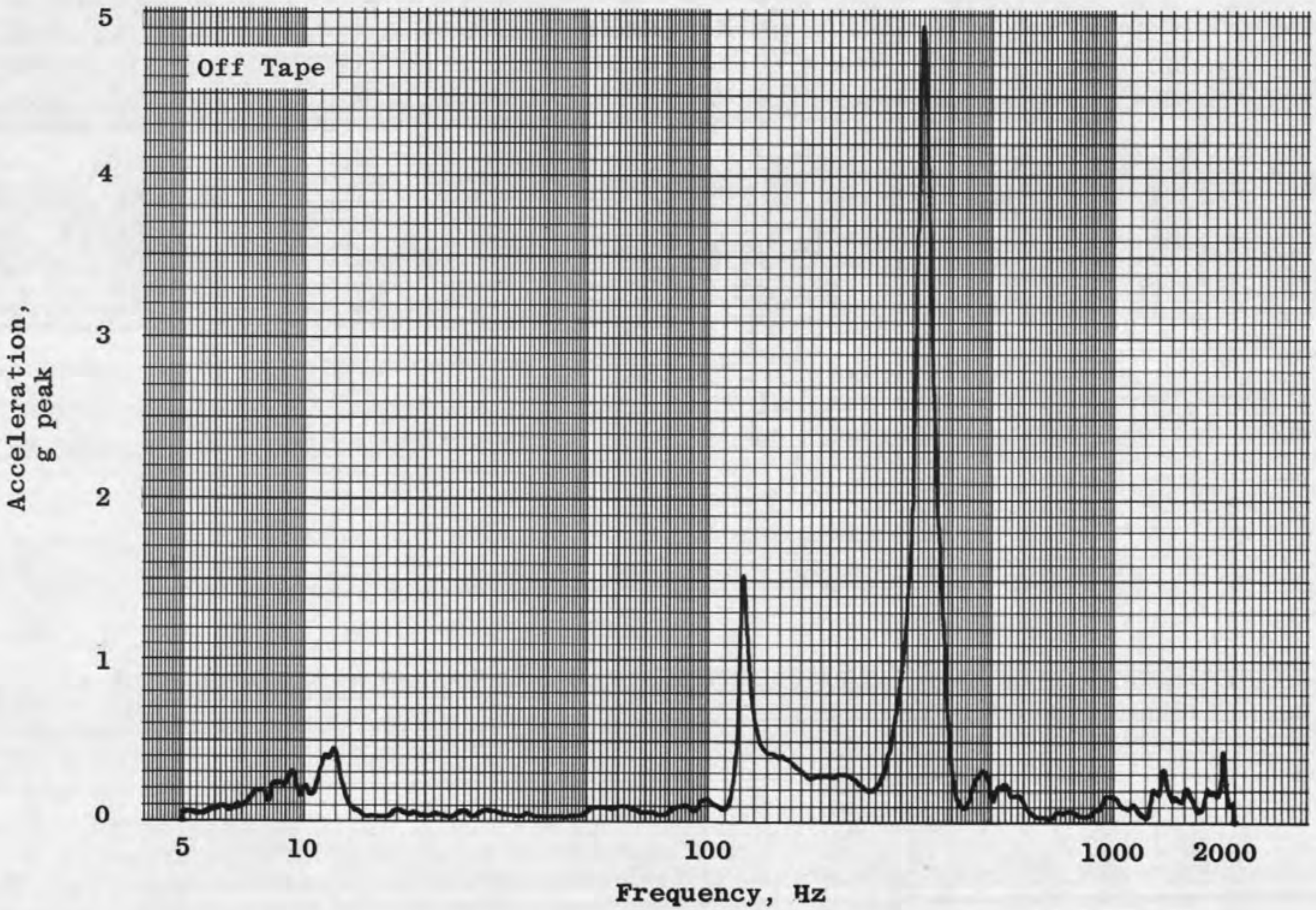
g. Accelerometer 3TR
Figure 8. Continued.



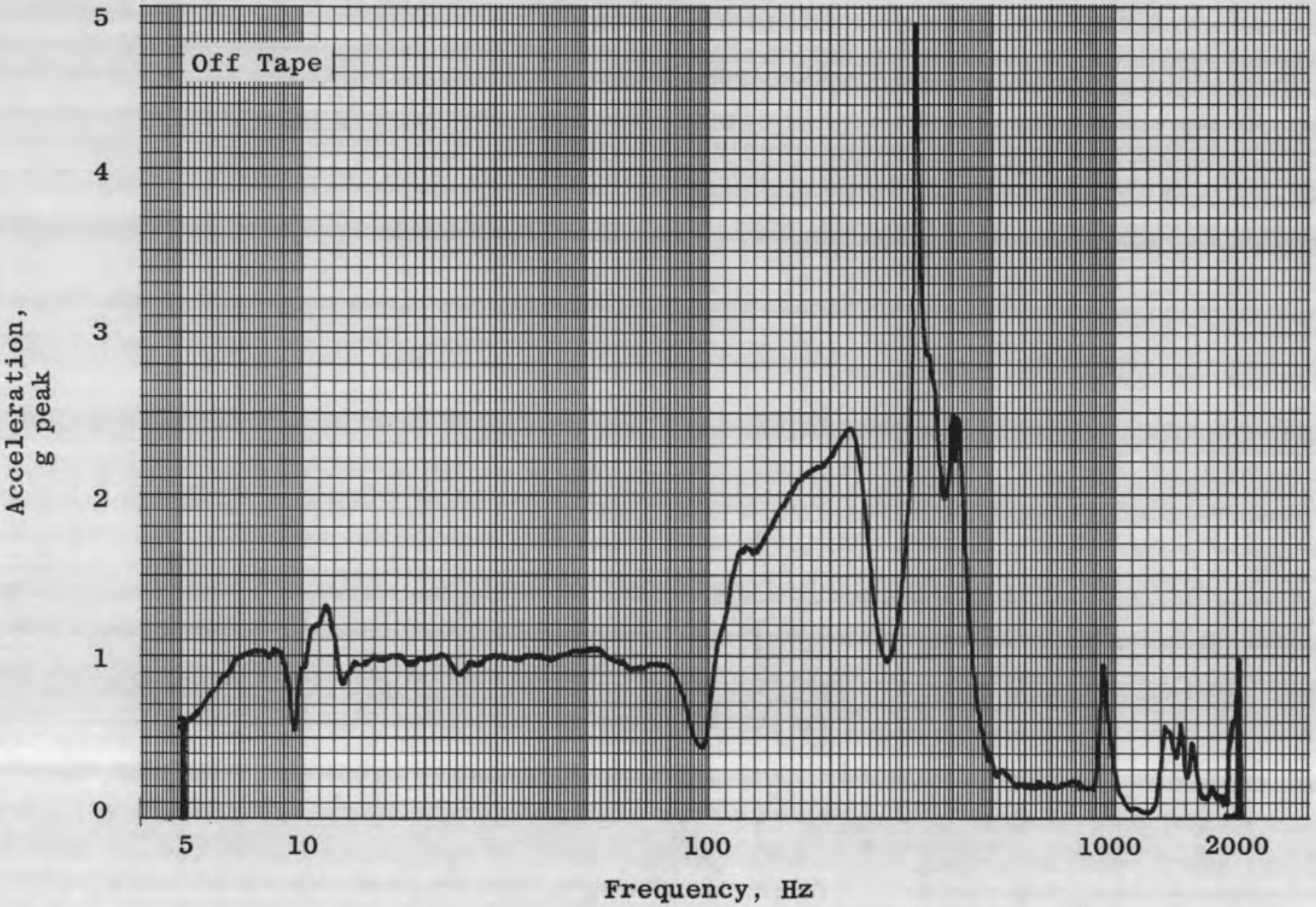
h. Accelerometer 4L
Figure 8. Continued.



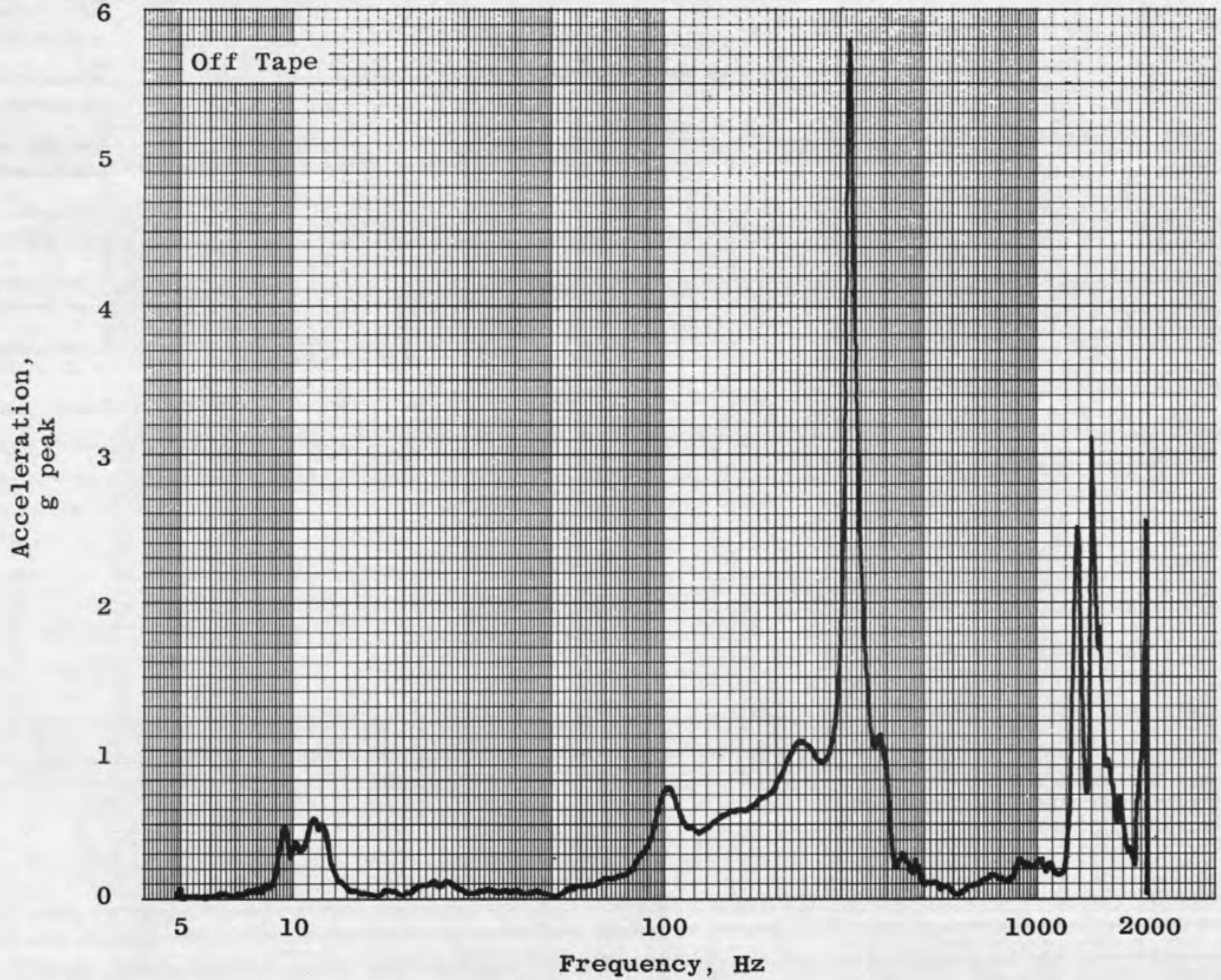
i. Accelerometer 4T
Figure 8. Continued.



j. Accelerometer 5T
Figure 8. Continued.

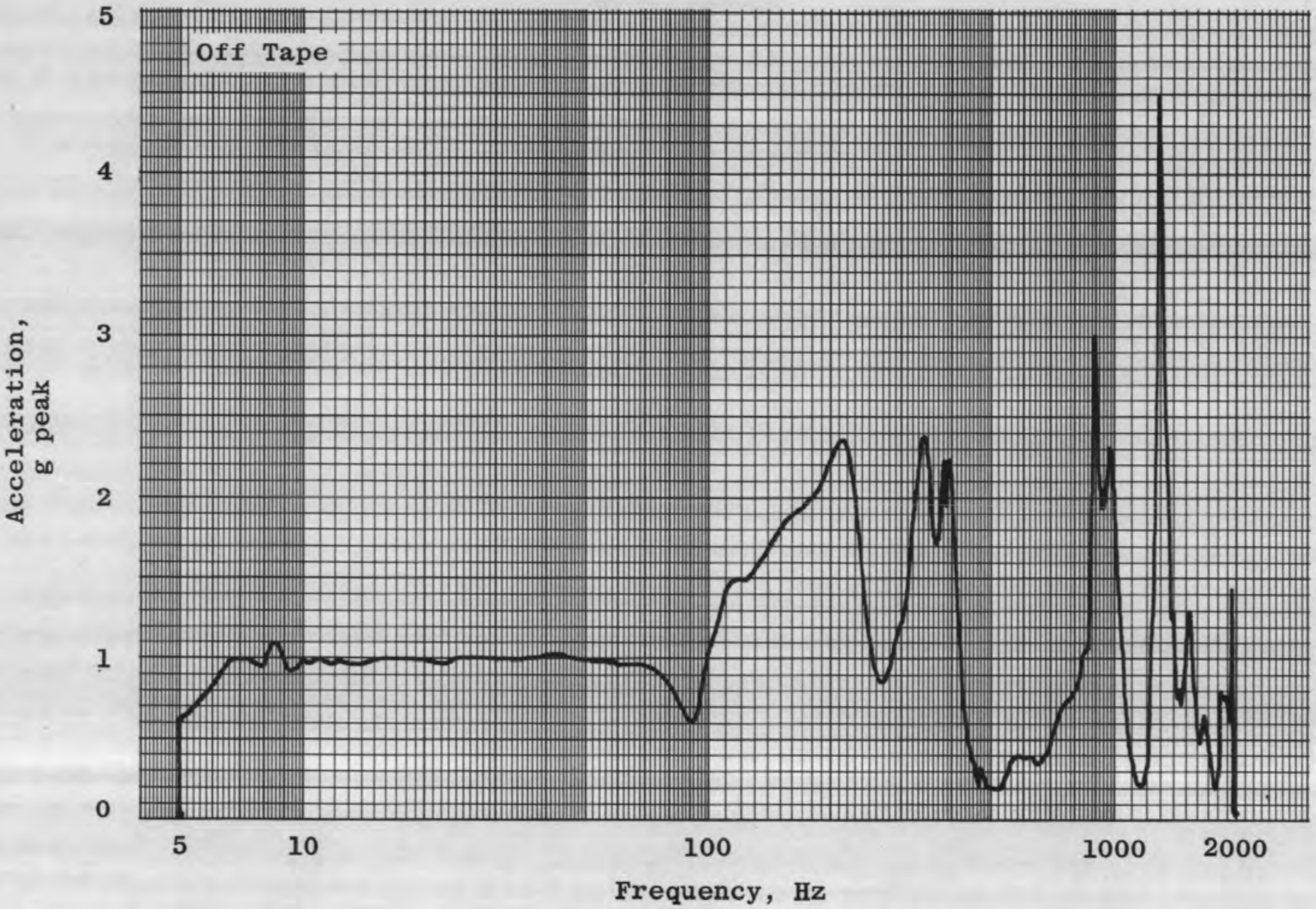


k. Accelerometer 6L
Figure 8. Continued.

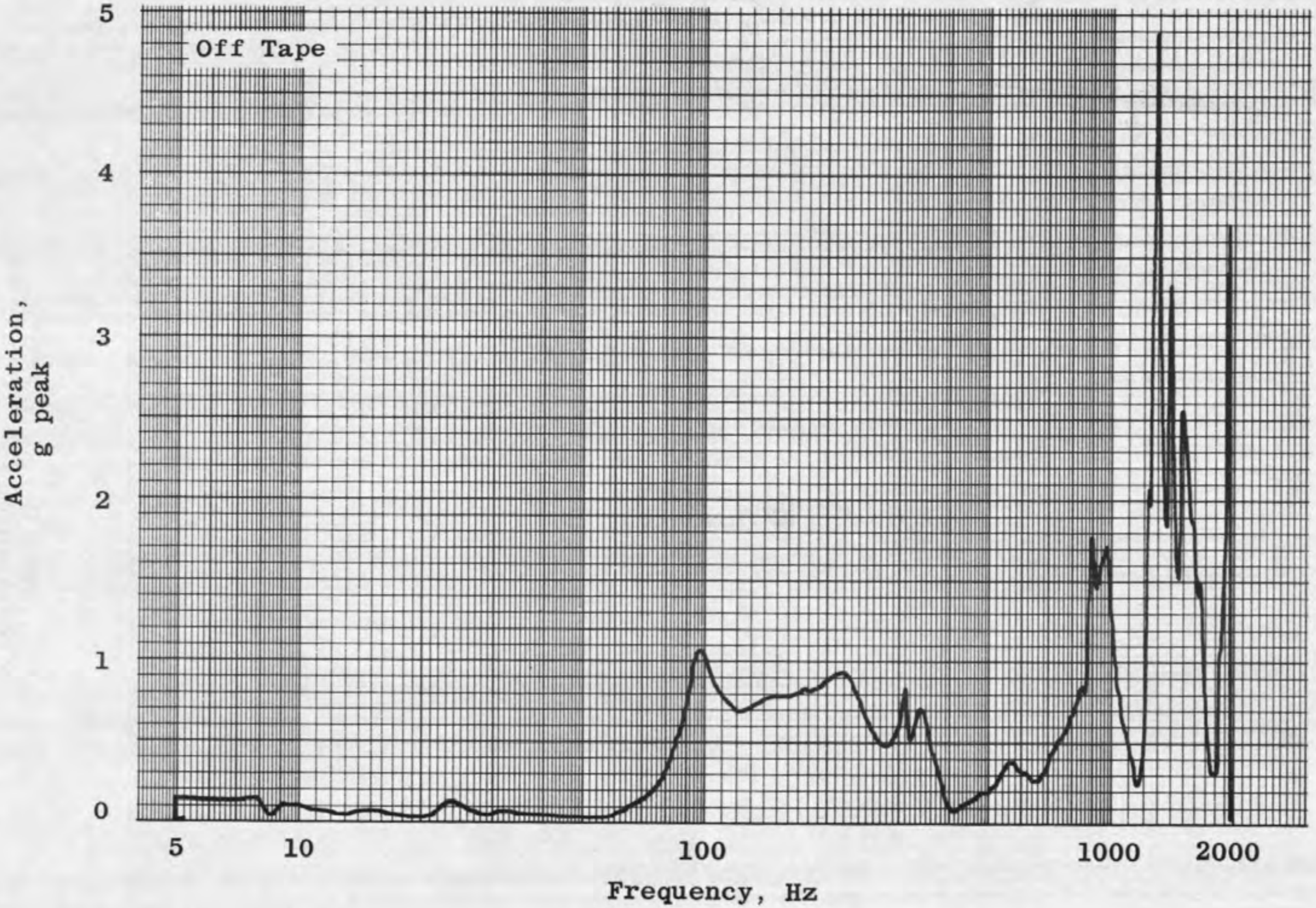


I. Accelerometer 6T

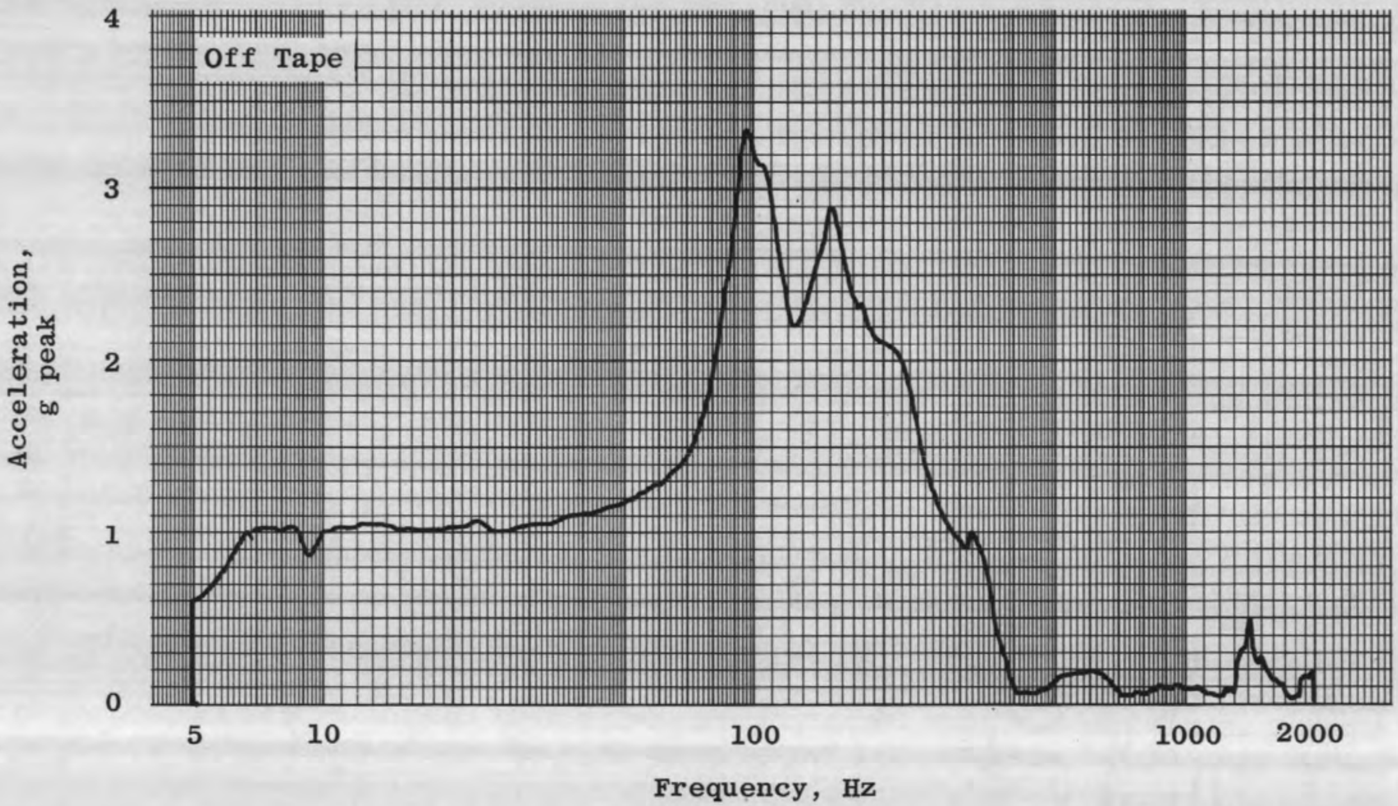
Figure 8. Continued.



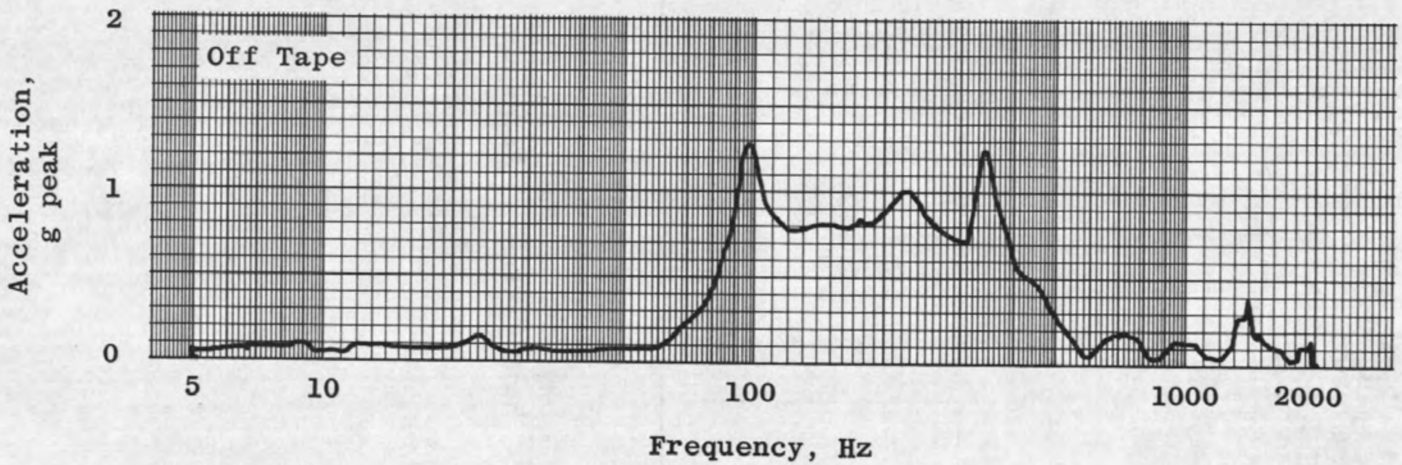
m. Accelerometer 7L
Figure 8. Continued.



n. Accelerometer 7T
Figure 8. Continued.



o. Accelerometer 8L
Figure 8. Continued.



p. Accelerometer 8T
Figure 8. Concluded.

Run Time							
-20 db		-10 db		Full Power		Other_____	
min	sec	min	sec	min	sec	min	sec
3			30		15		
	45		30	2	45		
	15		30				
	15		35				
			20				
			15				
			30				

Date: 1-11-77

a. Run time log
Figure 9. Random vibration: lateral axis.

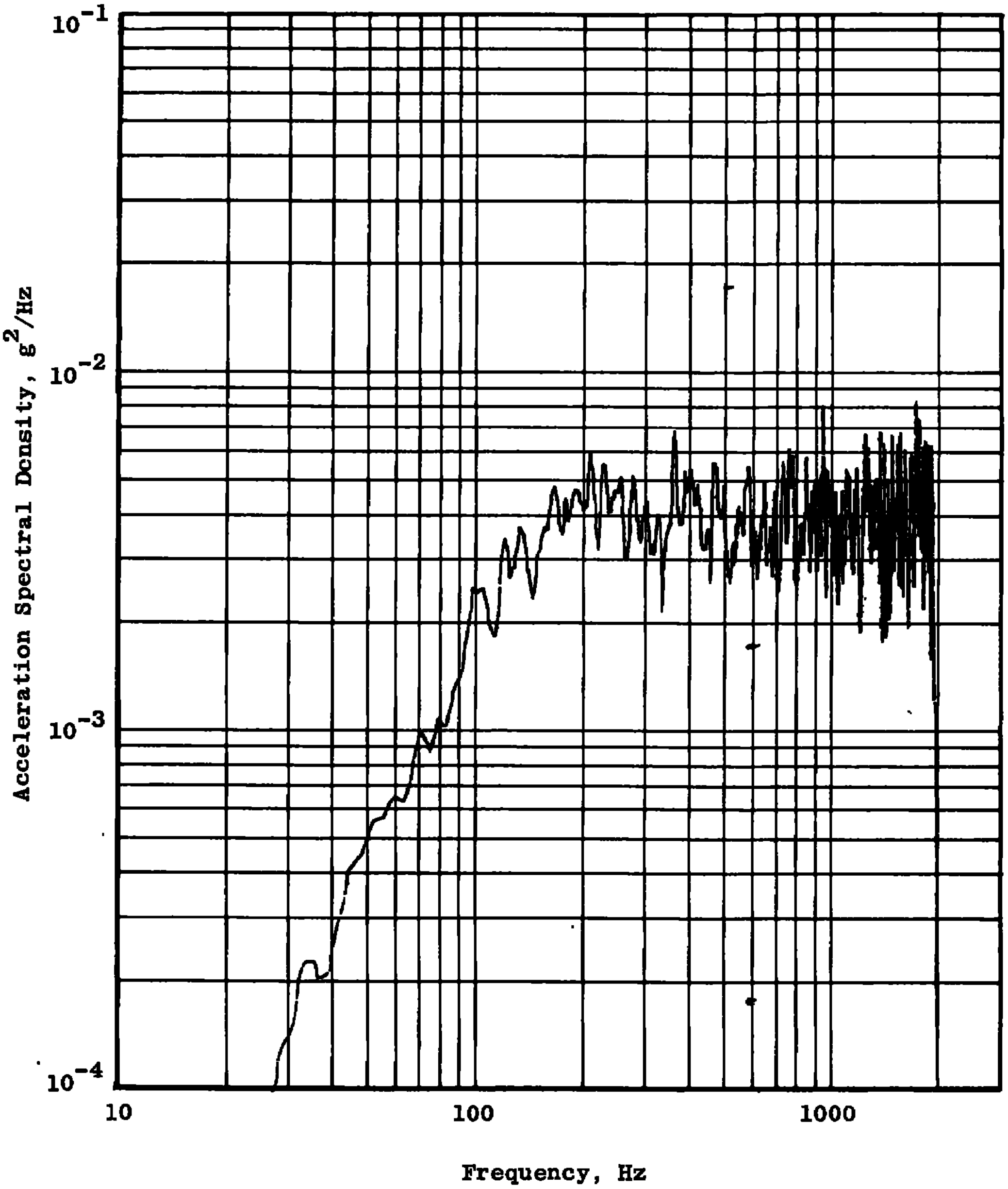
Analyzer: SD301C

Analyzer Bandwidth: 7.45 Hz

Accelerometer: 1L

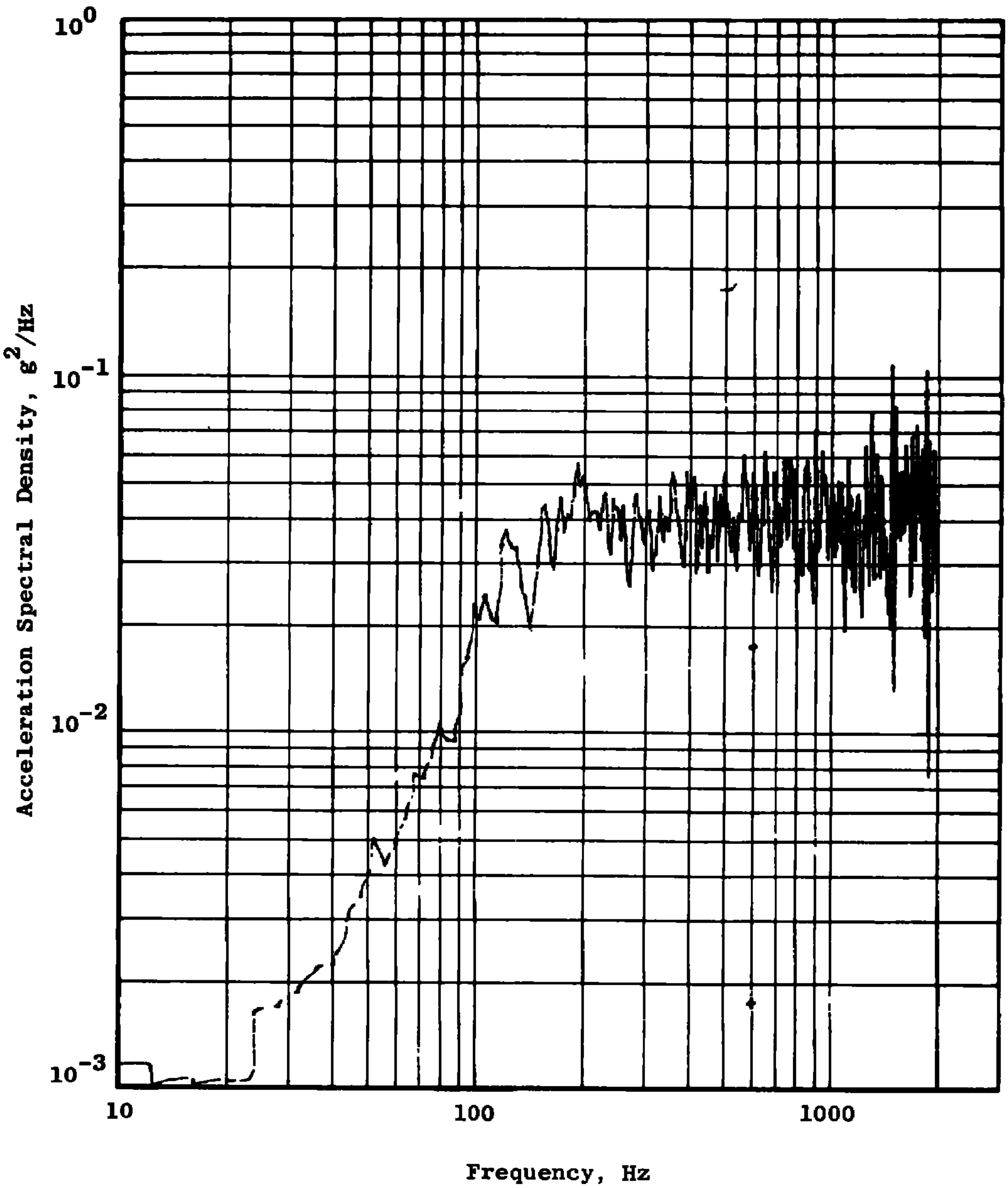
Date: 1-11-77

Remarks: Online Burst of 30 sec, -10 db



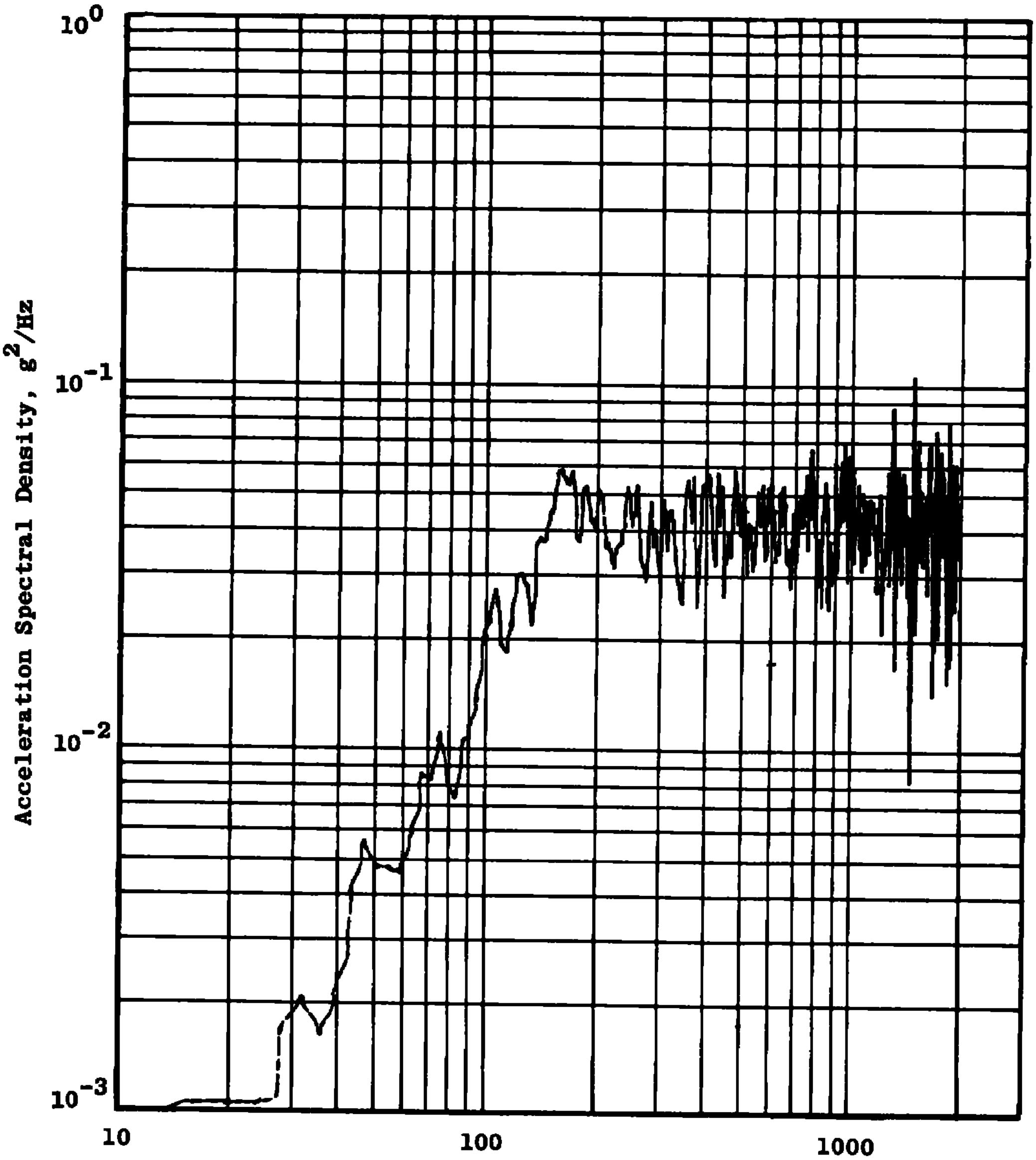
b. -10 db spectrum
Figure 9. Continued.

Vibration Level: 9.3 g rms
Analyzer: SD301C
Analyzer Bandwidth: 7.45 Hz
Accelerometer: 1L
Date: 1-11-77
Remarks: 15-sec Burst No. 1
Online
Full Power

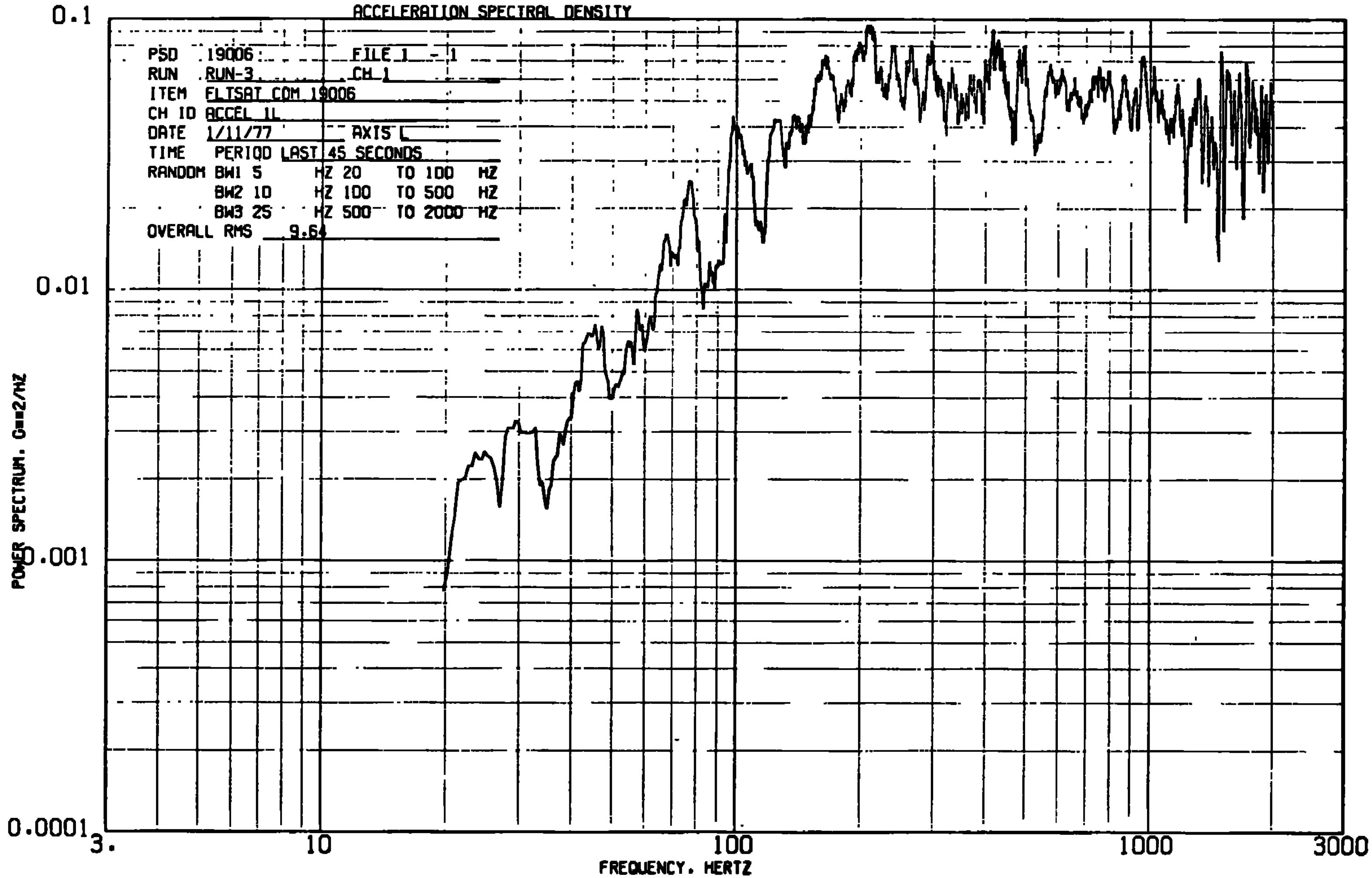


c. 15-sec equalization run spectrum
Figure 9. Continued.

Vibration Level: 9.3 g rms
Analyzer: SD301C
Analyzer Bandwidth: 7.45 Hz
Accelerometer: 1L
Date: 1-11-77
Remarks: Full Level Run
Off Tape
2 min 45 sec

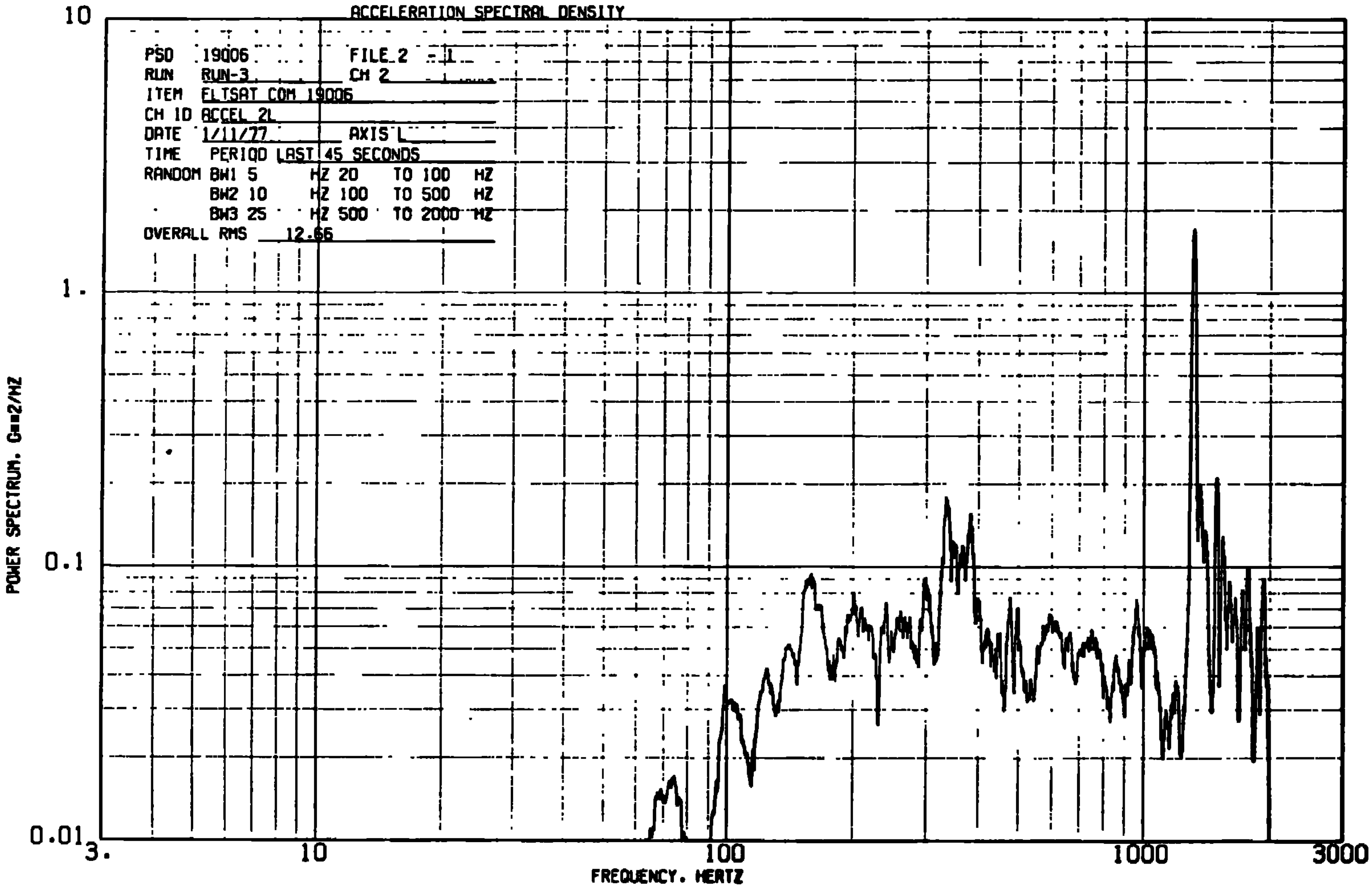


d. 2-min 45-sec run spectrum
Figure 9. Concluded.

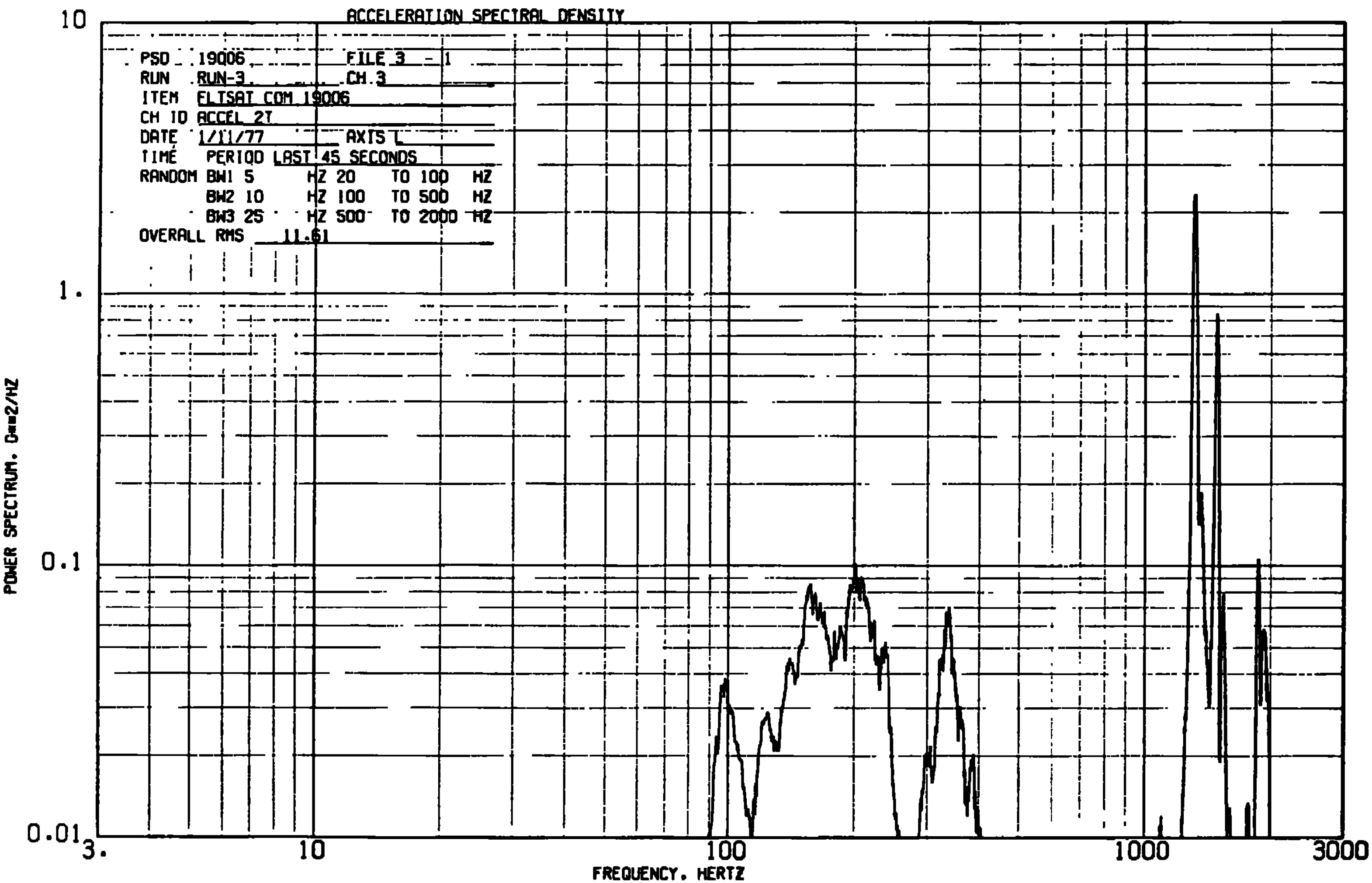


a. Accelerometer 1L (control)

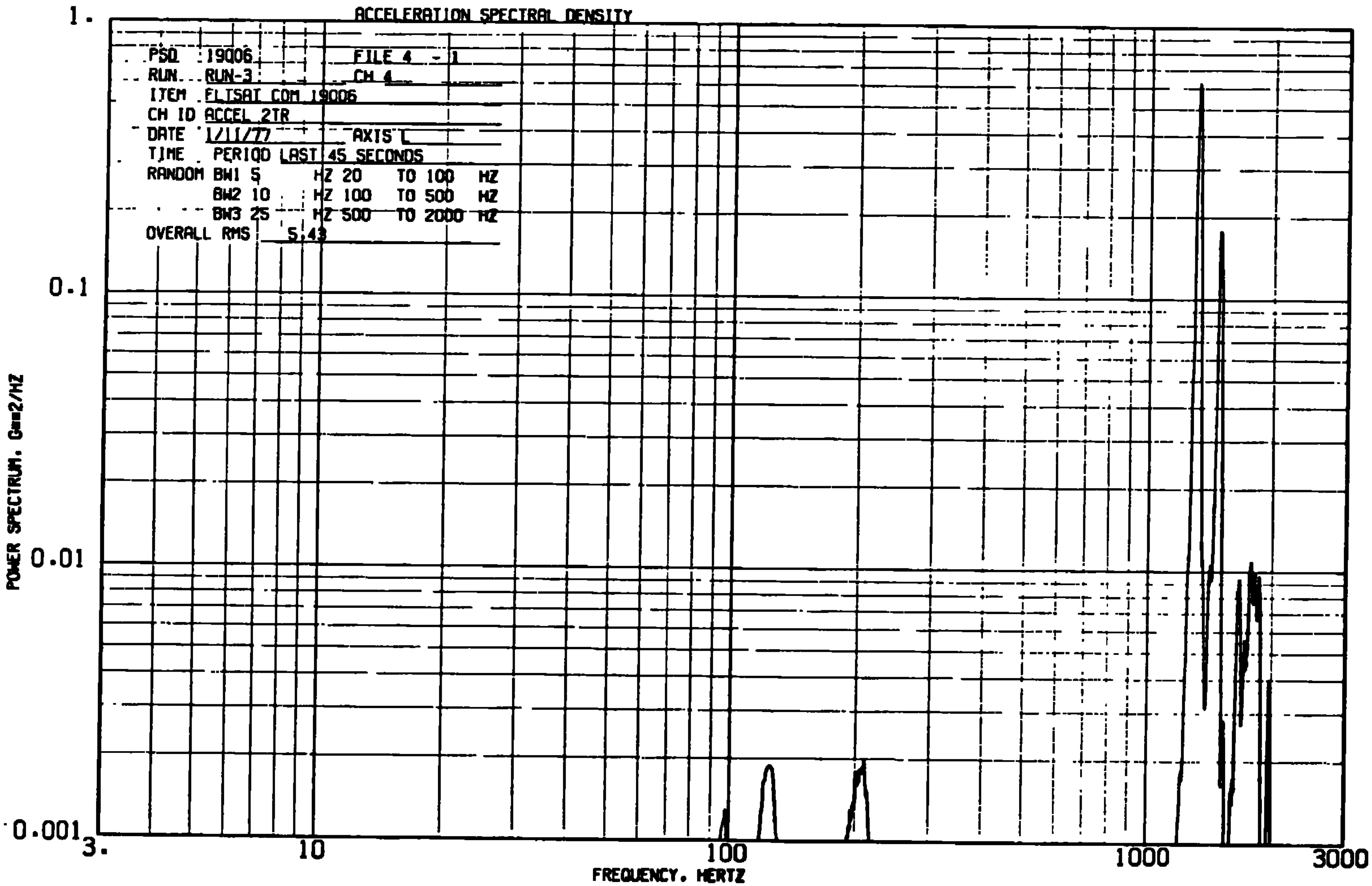
Figure 10. Random vibration: lateral axis - digital analysis.



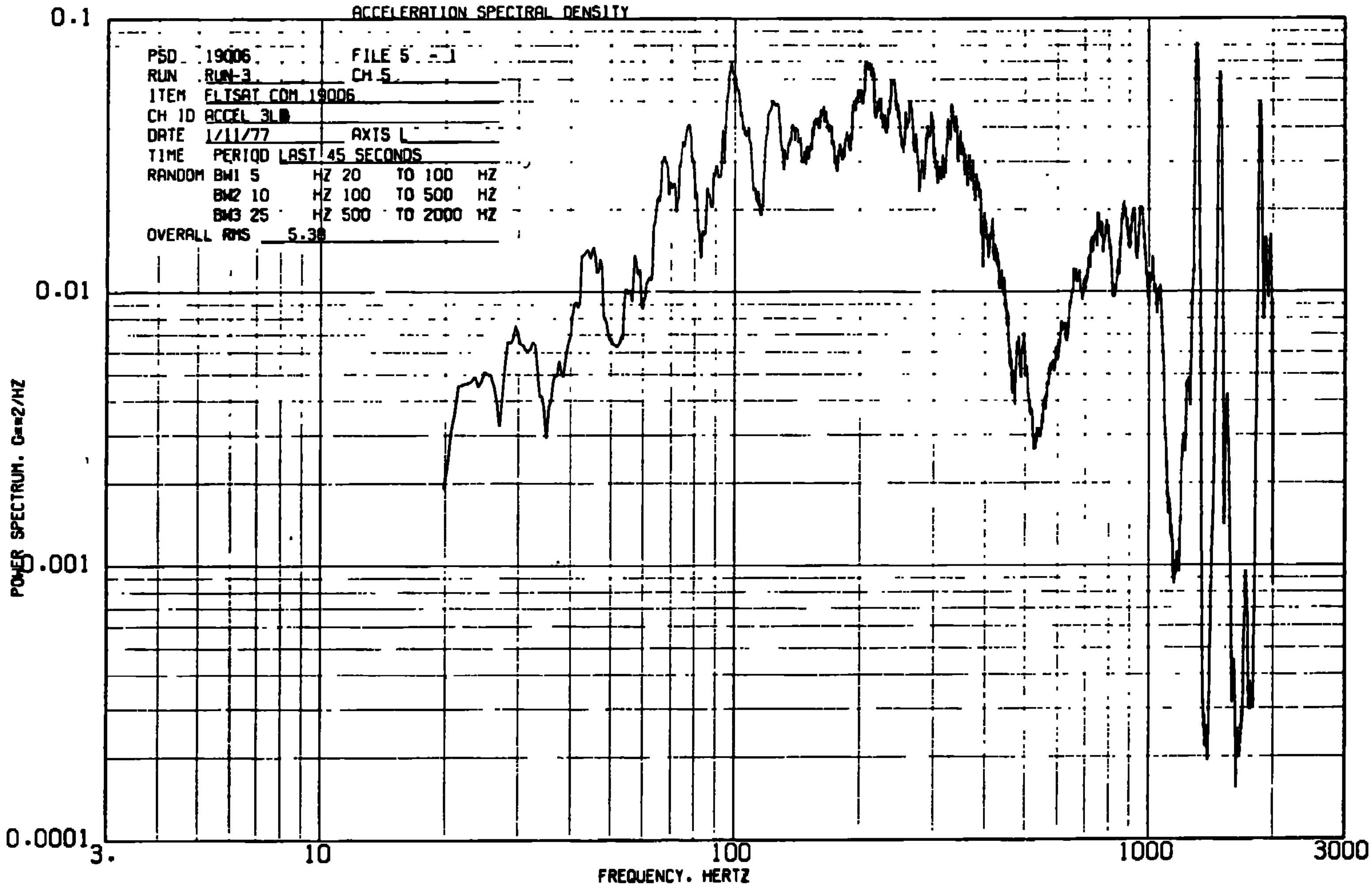
b. Accelerometer 2L
Figure 10. Continued.



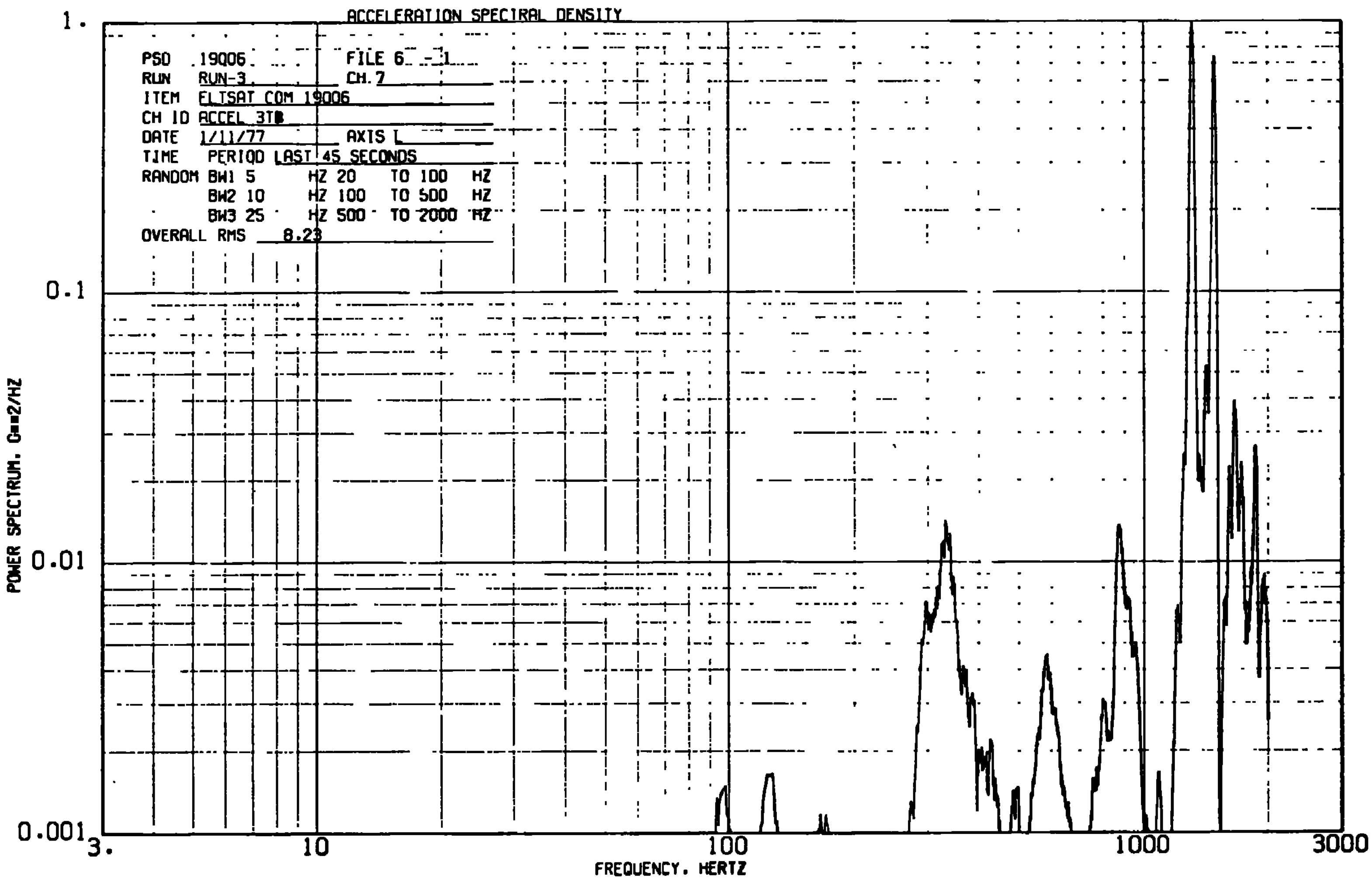
c. Accelerometer 2T
Figure 10. Continued.



d. Accelerometer 2TR
Figure 10. Continued.

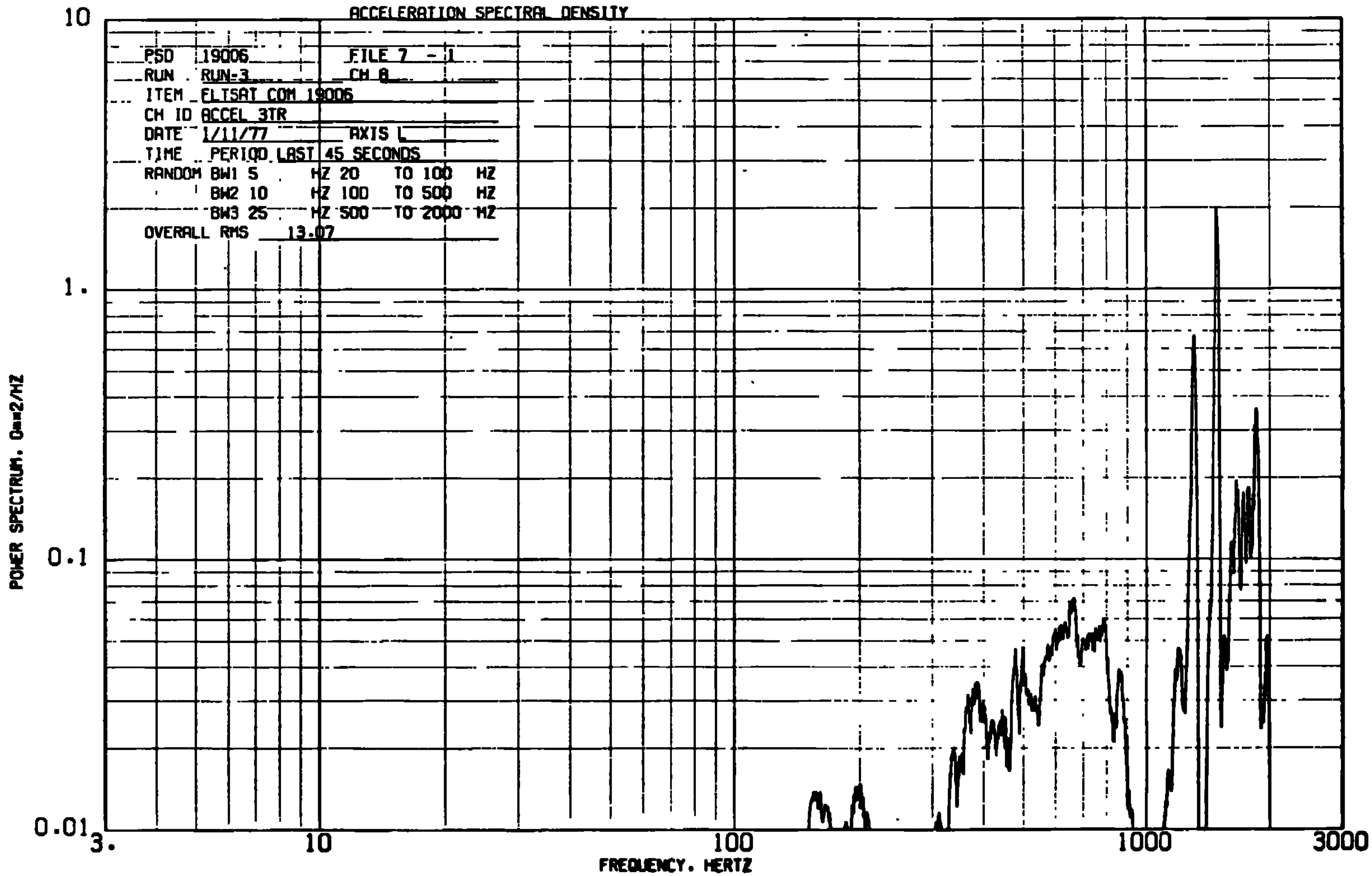


e. Accelerometer 3L
Figure 10. Continued.

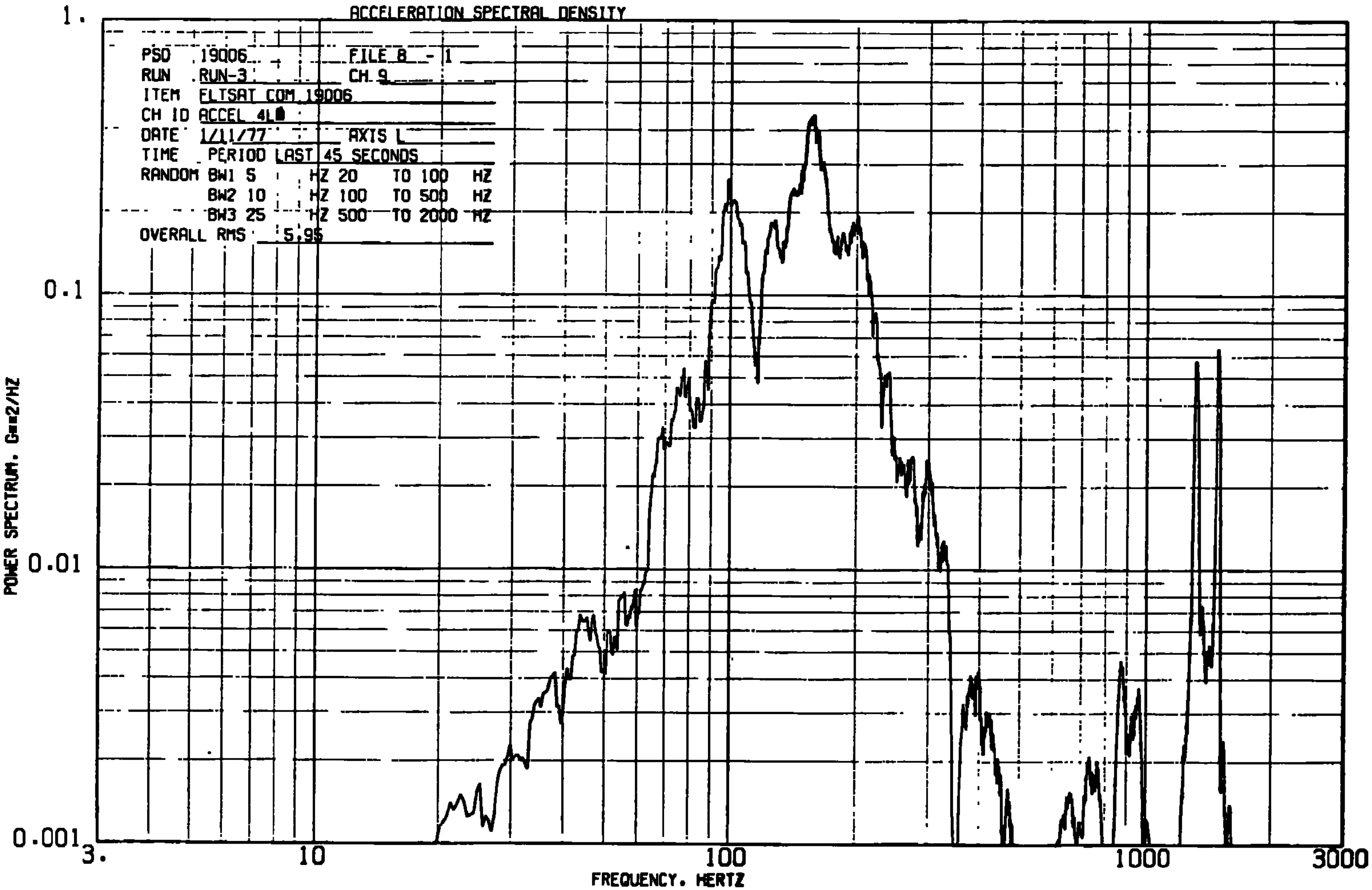


f. Accelerometer 3T

Figure 10. Continued.

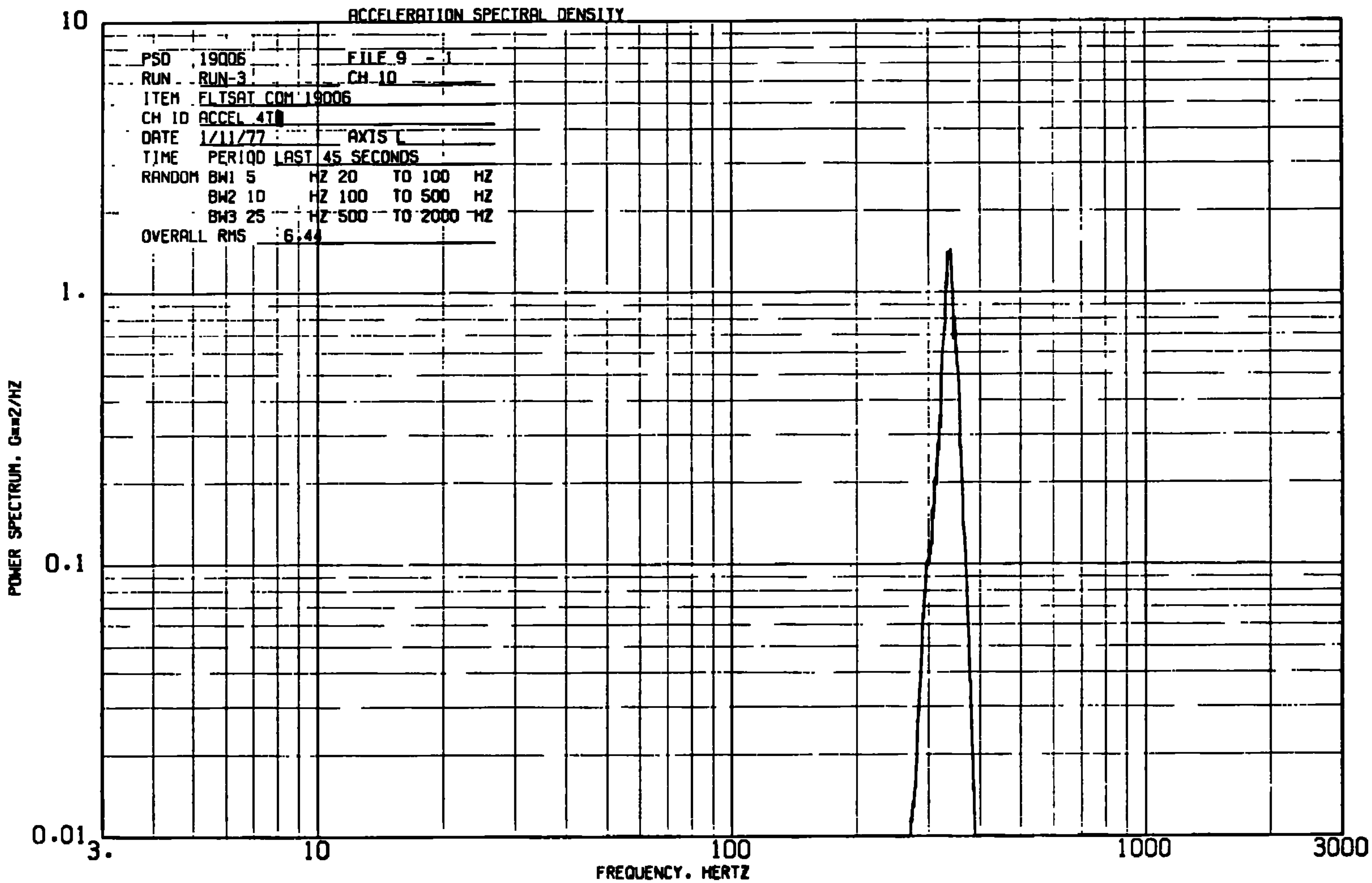


g. Accelerometer 3TR
Figure 10. Continued.

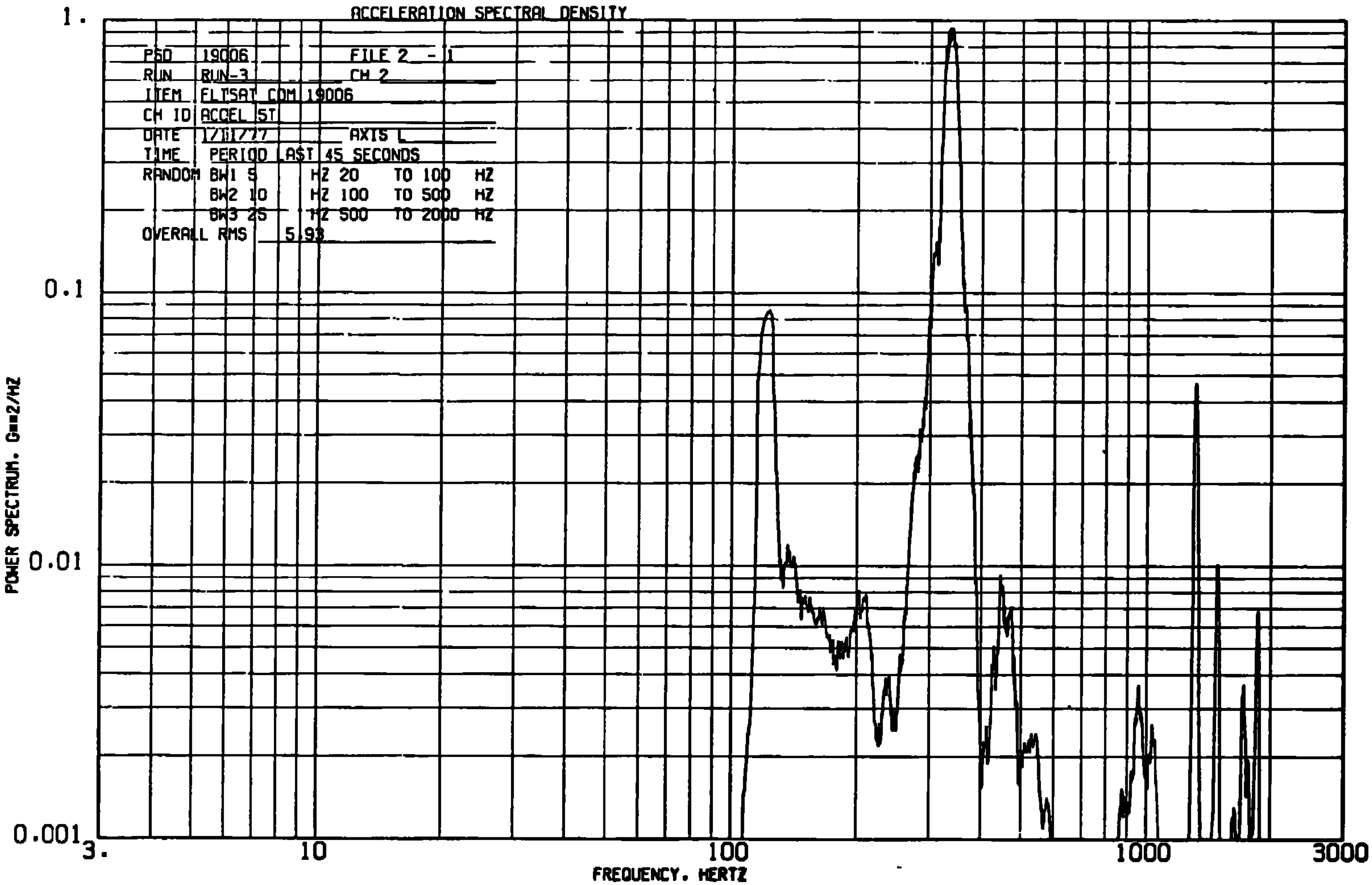


h. Accelerometer 4L

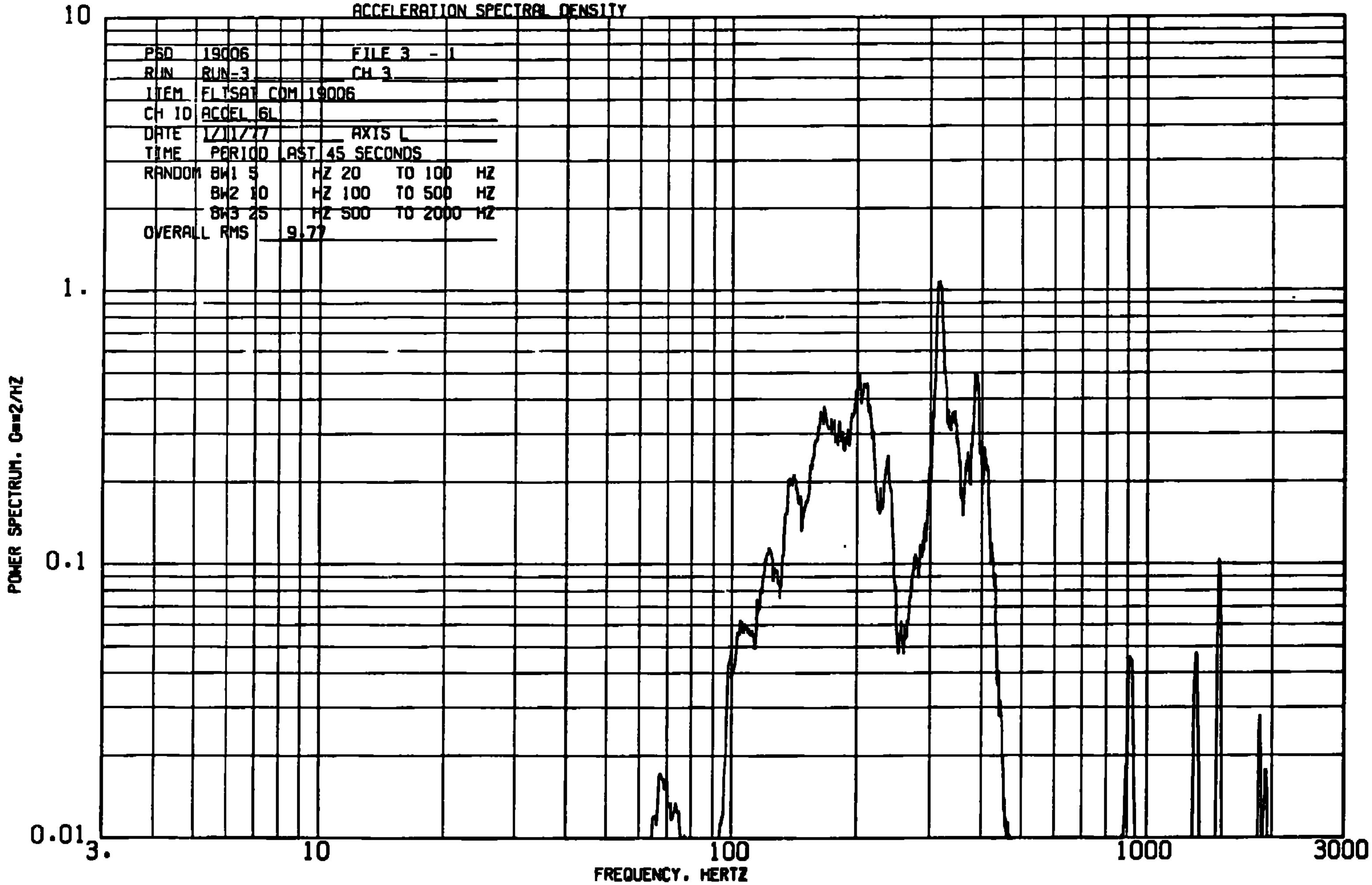
Figure 10. Continued.



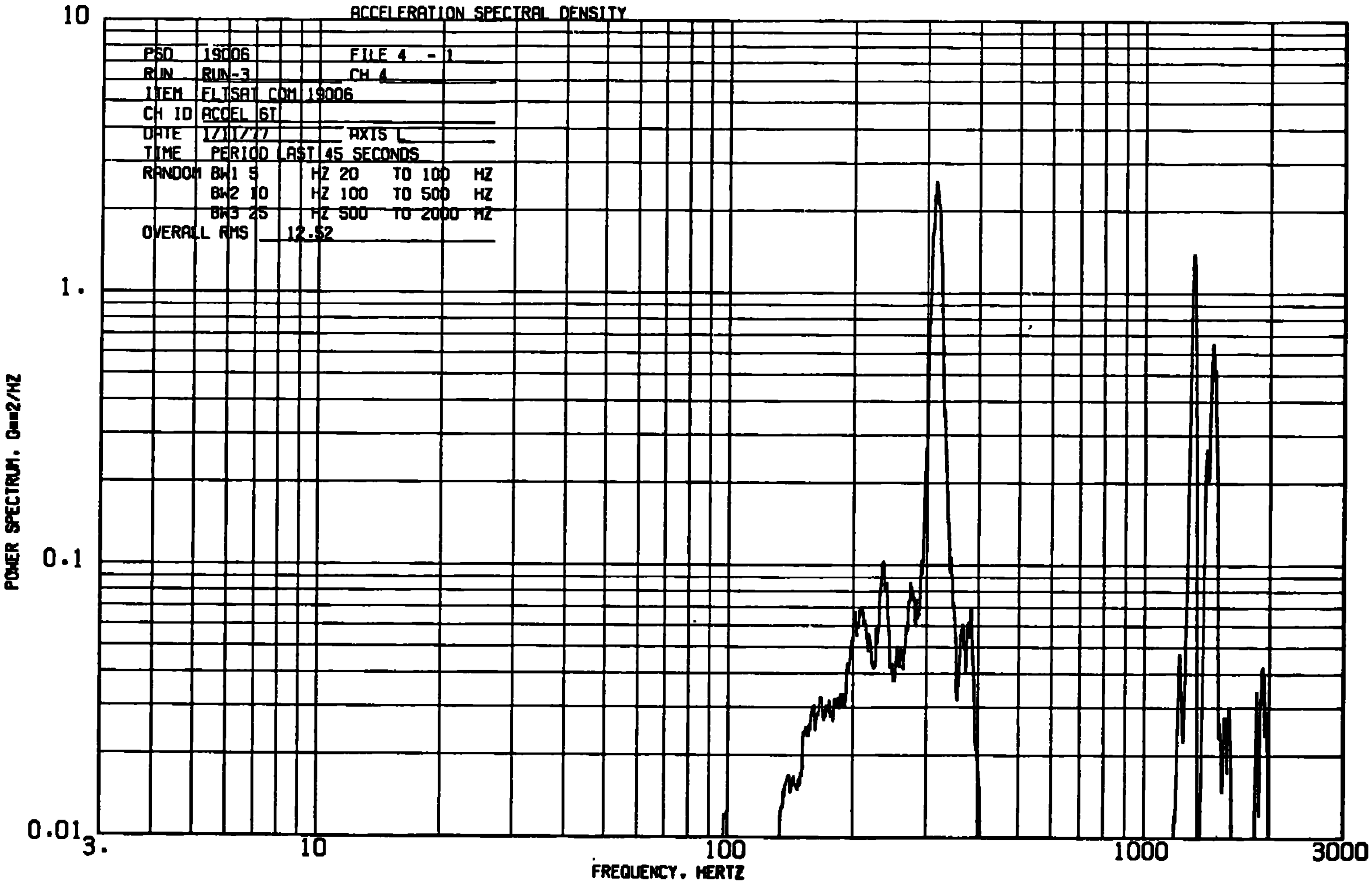
i. Accelerometer 4T
Figure 10. Continued.



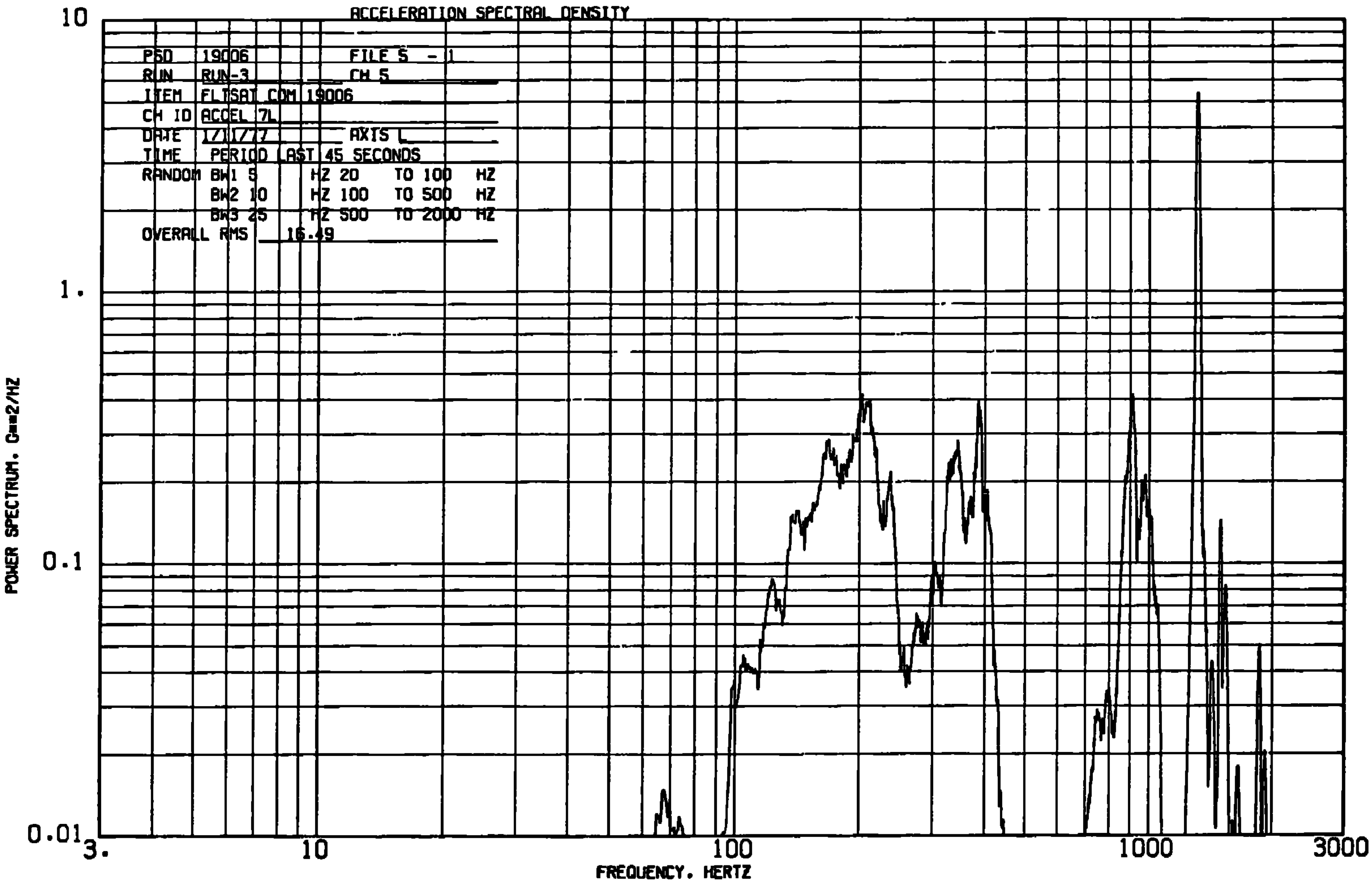
j. Accelerometer 5T
Figure 10. Continued.



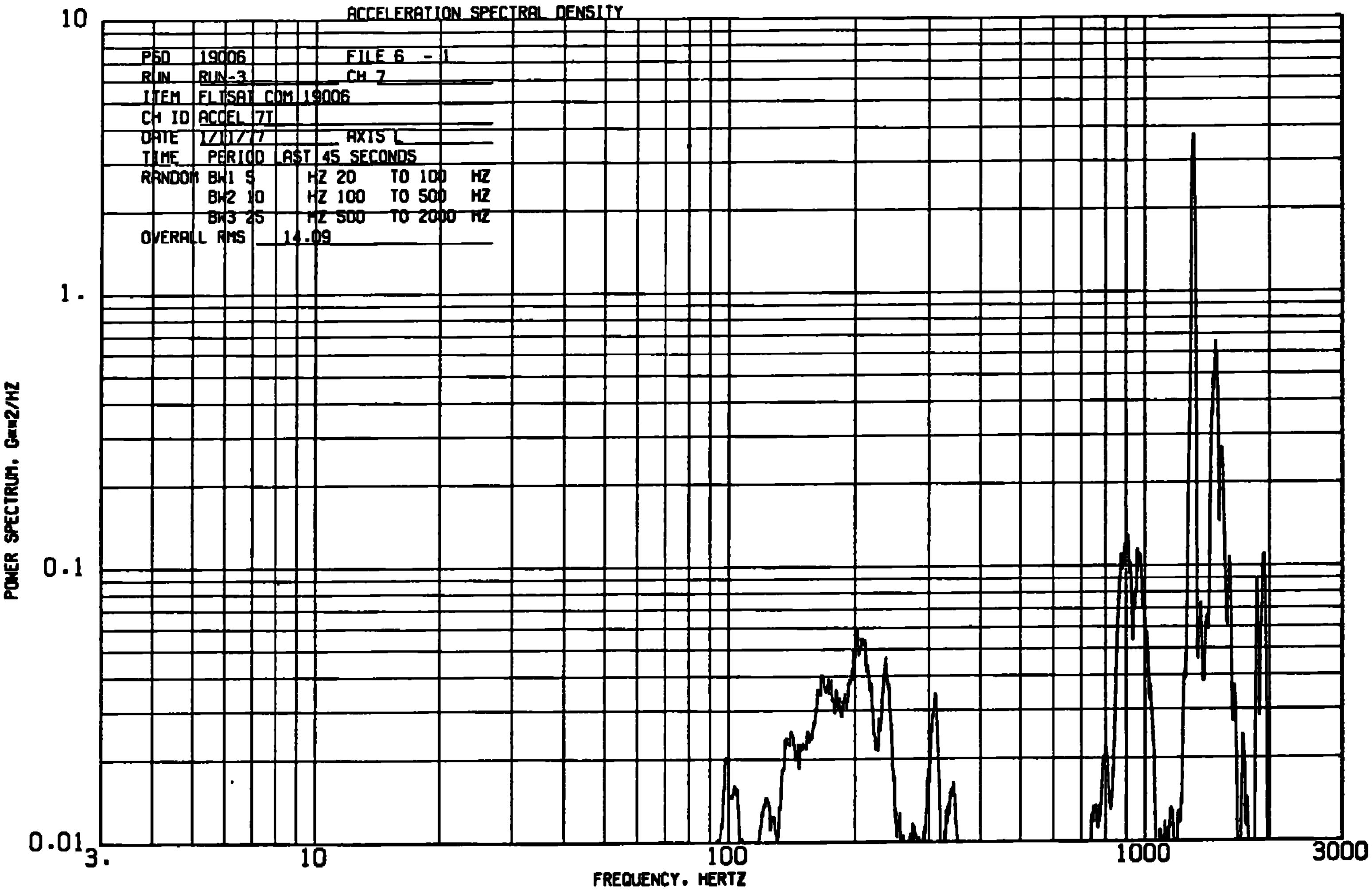
k. Accelerometer 6L
Figure 10. Continued.



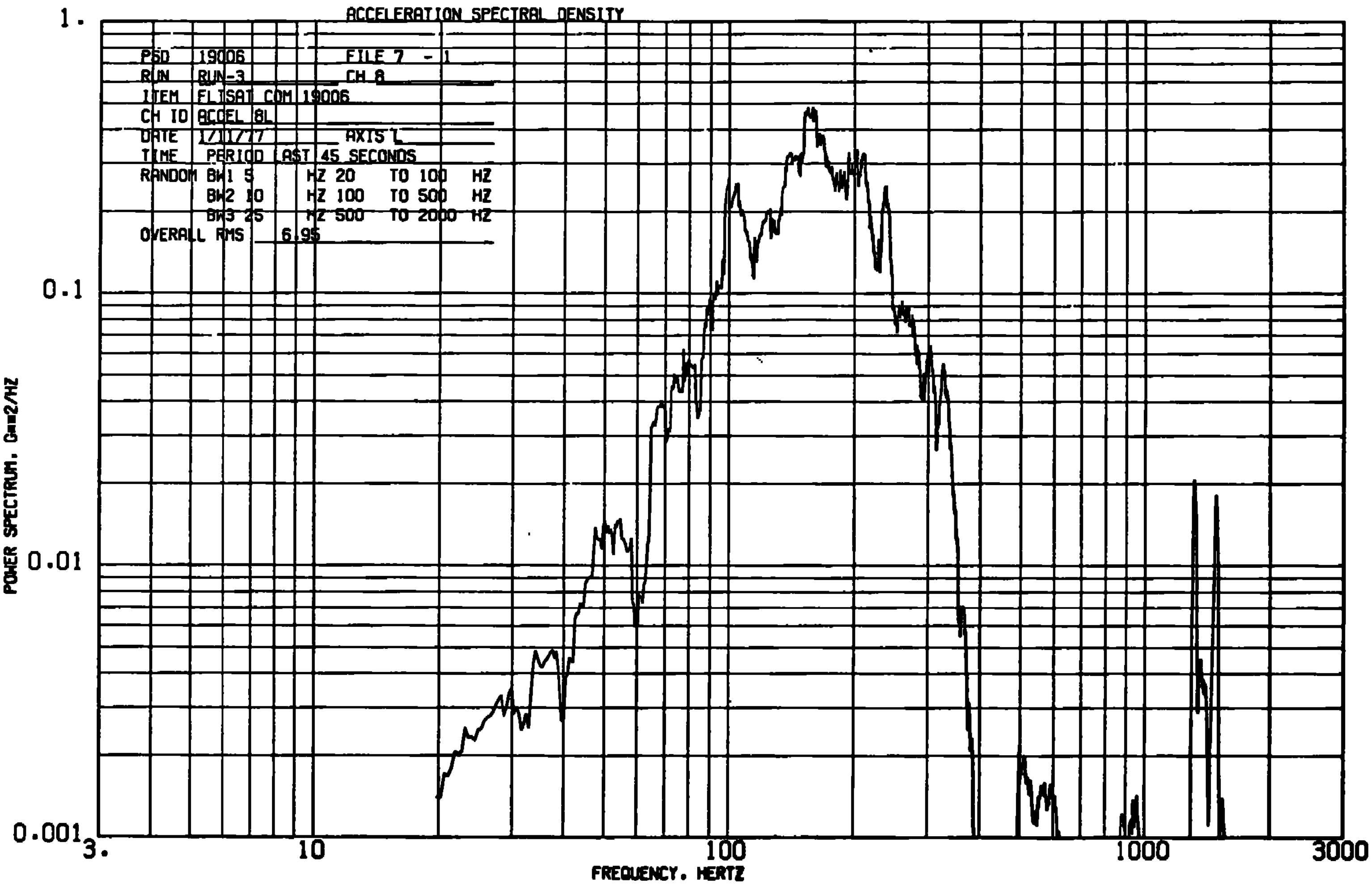
I. Accelerometer 6T
Figure 10. Continued.



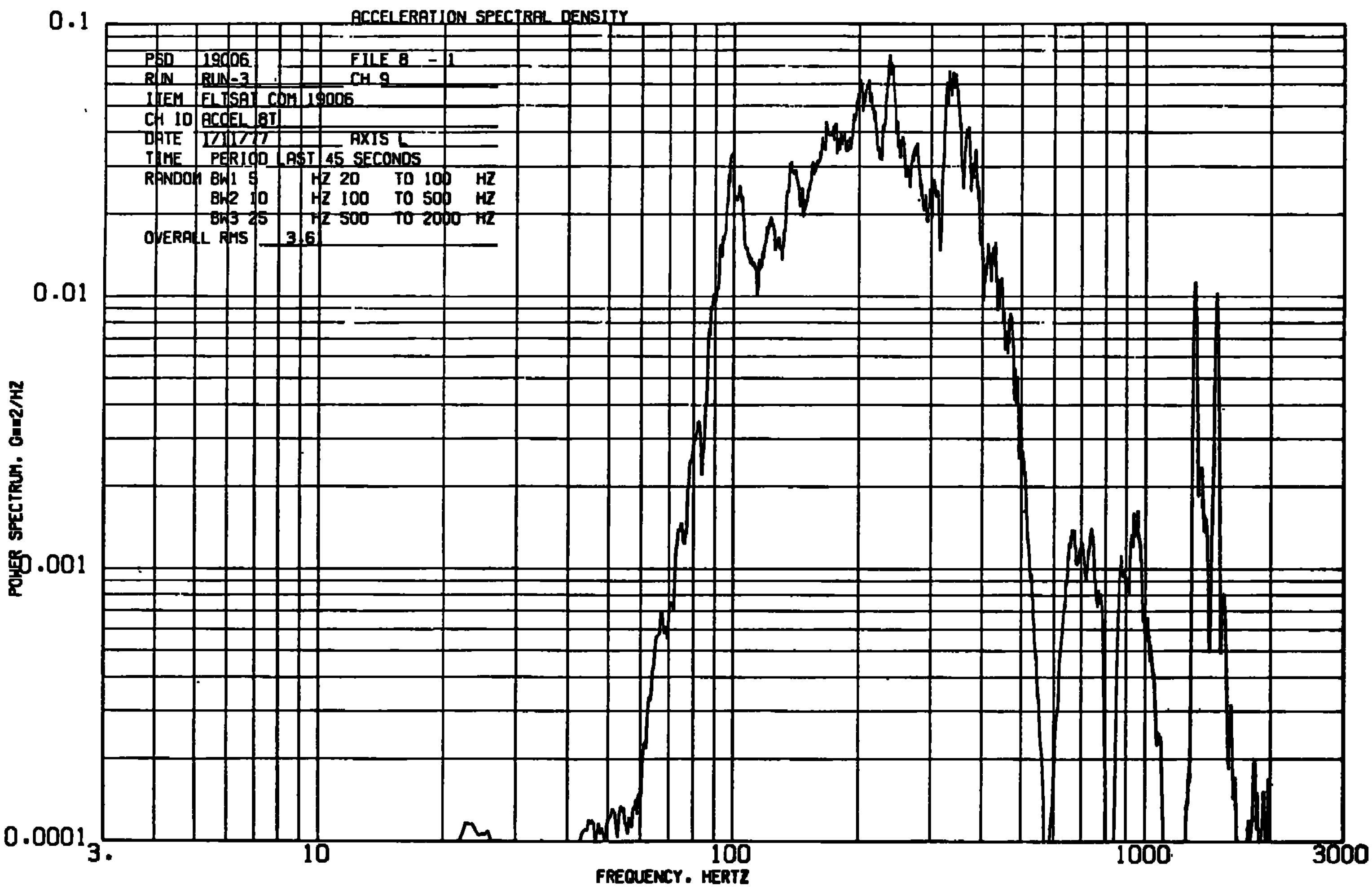
m. Accelerometer 7L
Figure 10. Continued.



n. Accelerometer 7T
Figure 10. Continued.



o. Accelerometer 8L
Figure 10. Continued.



p. Accelerometer 8T

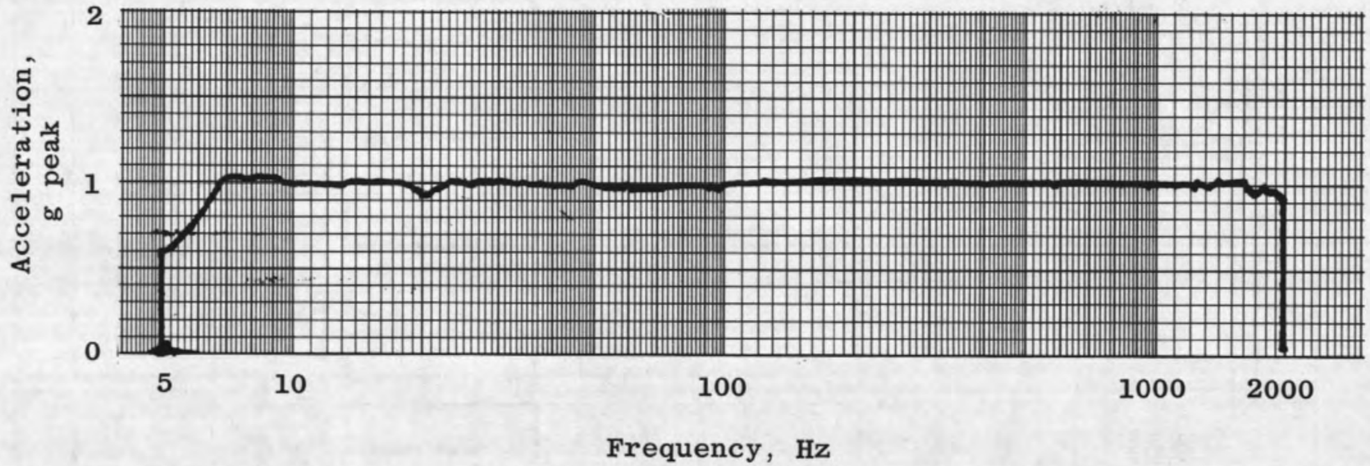
Figure 10. Concluded.

BW_1: 5 Hz from 5 to 40 Hz

BW_2: 50 Hz from 40 to 2000 Hz

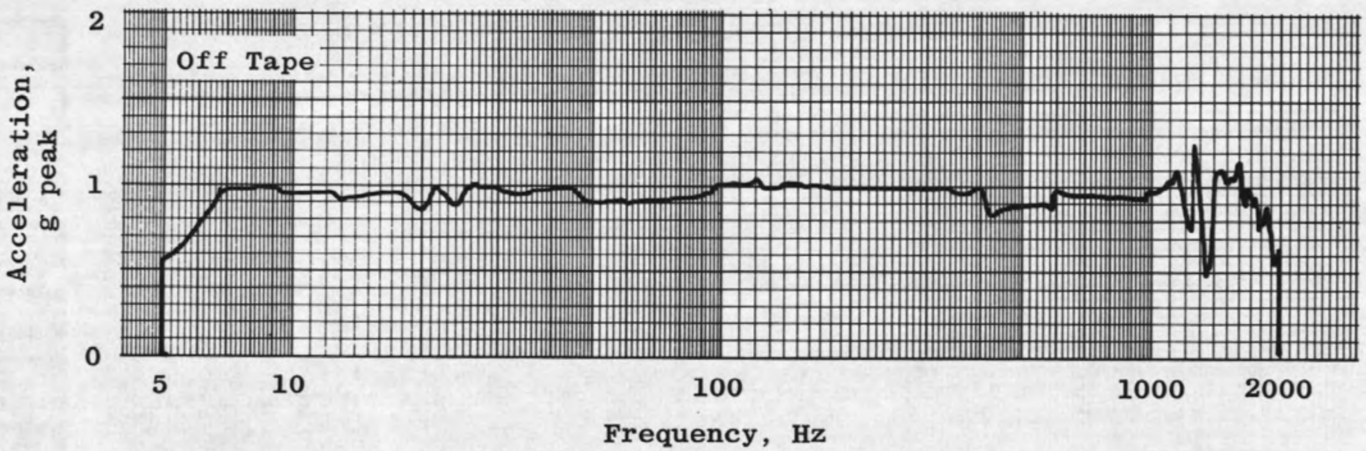
Date: 1/12/77

Remarks: Online, 1.0-g Run

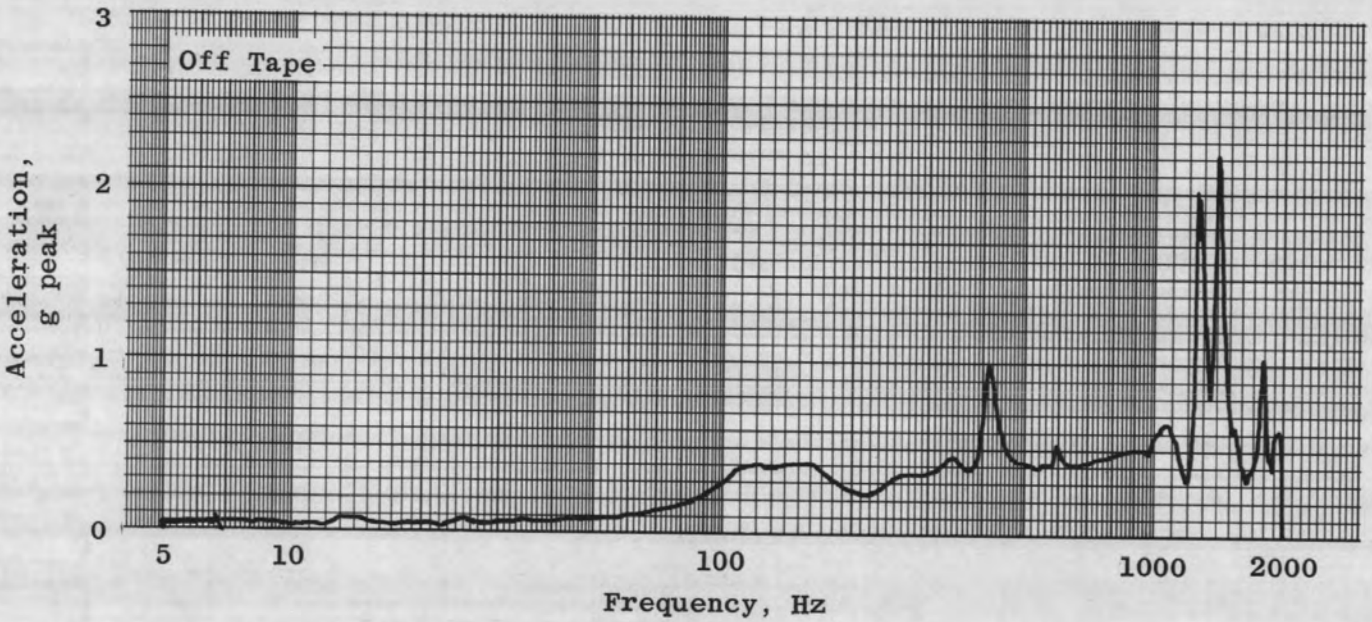


a. Accelerometer 1T (control)

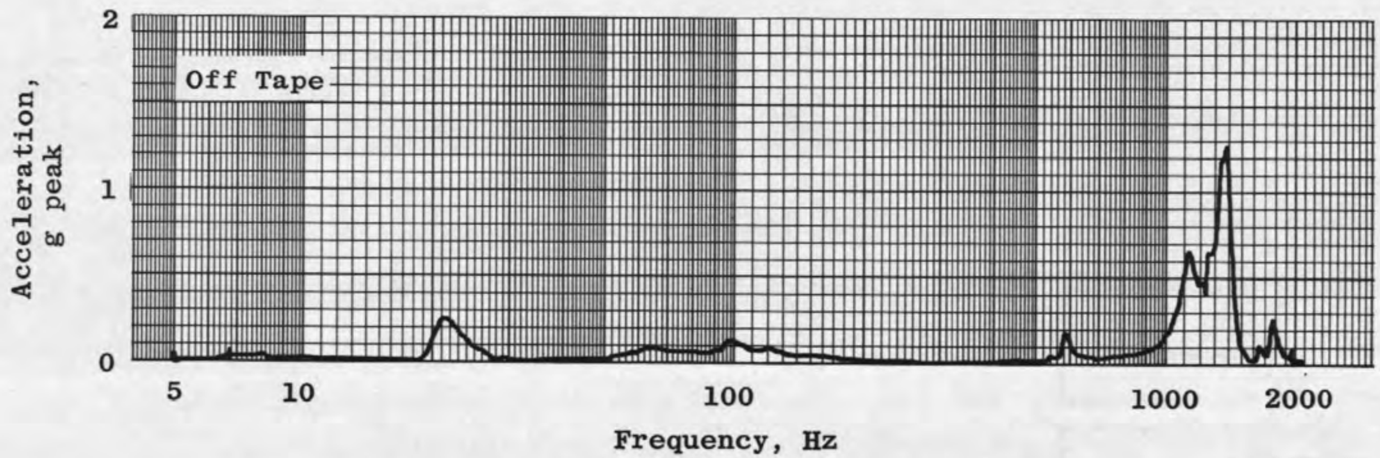
Figure 11. 1-g sine vibration: thrust axis.



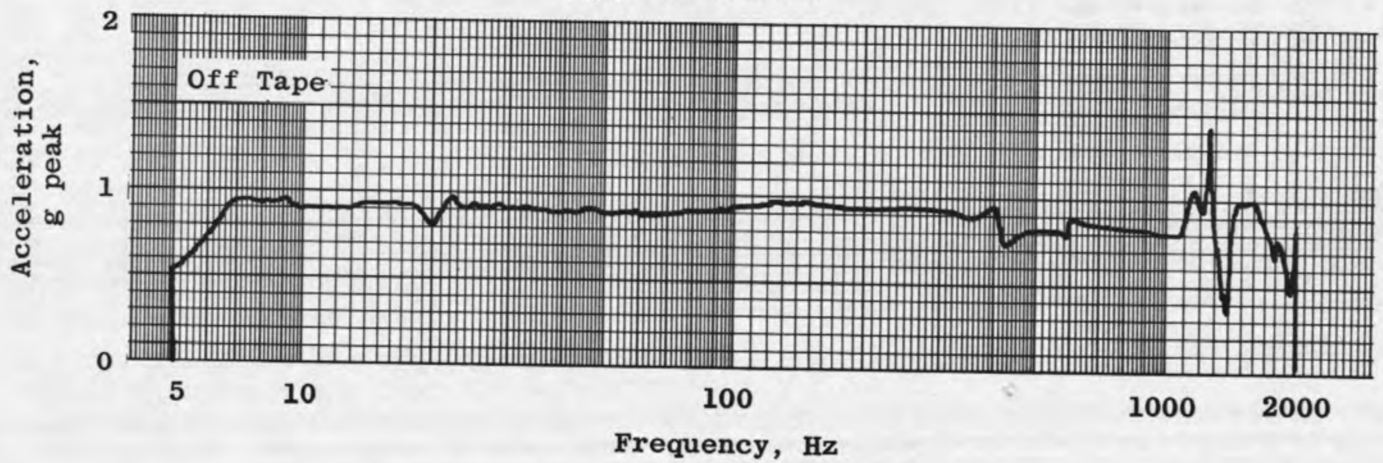
b. Accelerometer 2T
Figure 11. Continued.



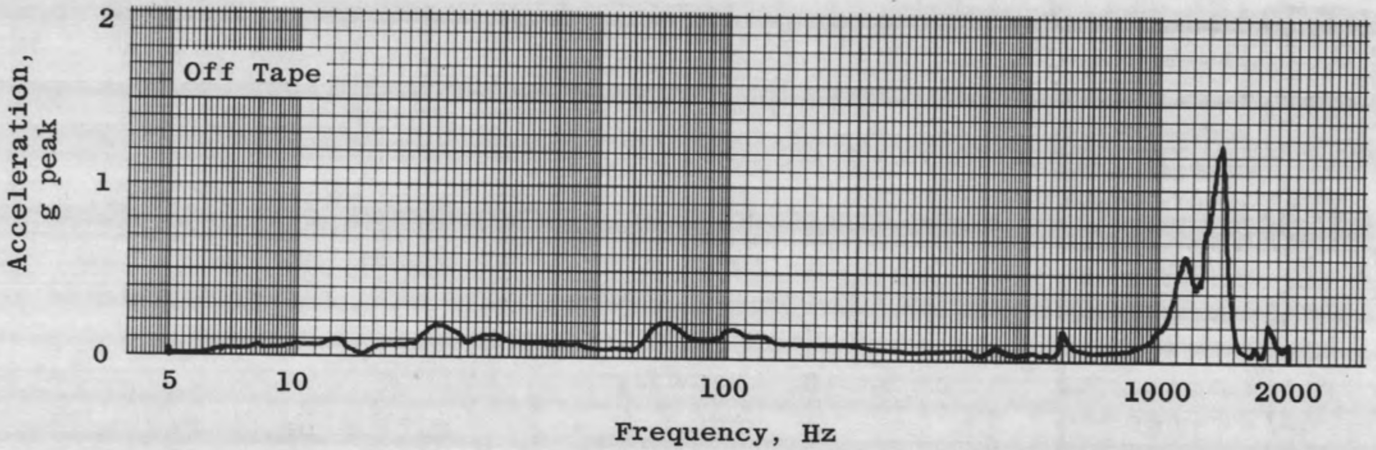
c. Accelerometer 2L
Figure 11. Continued.



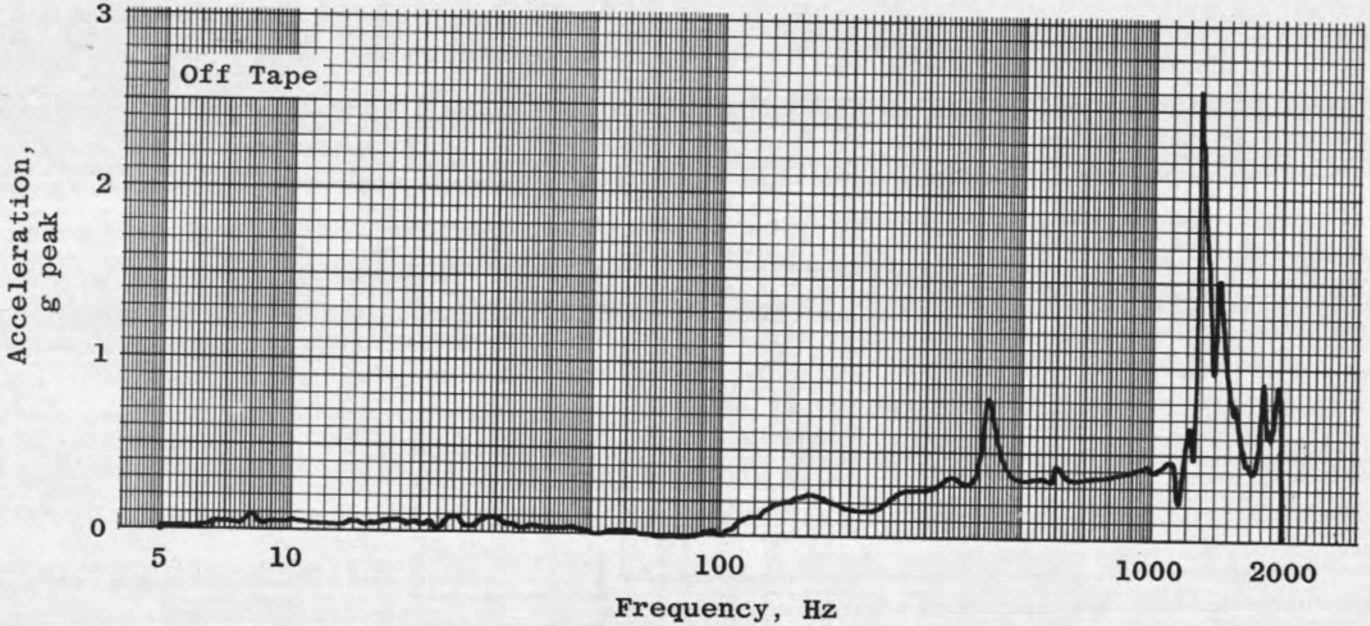
d. Accelerometer 2TR
Figure 11. Continued.



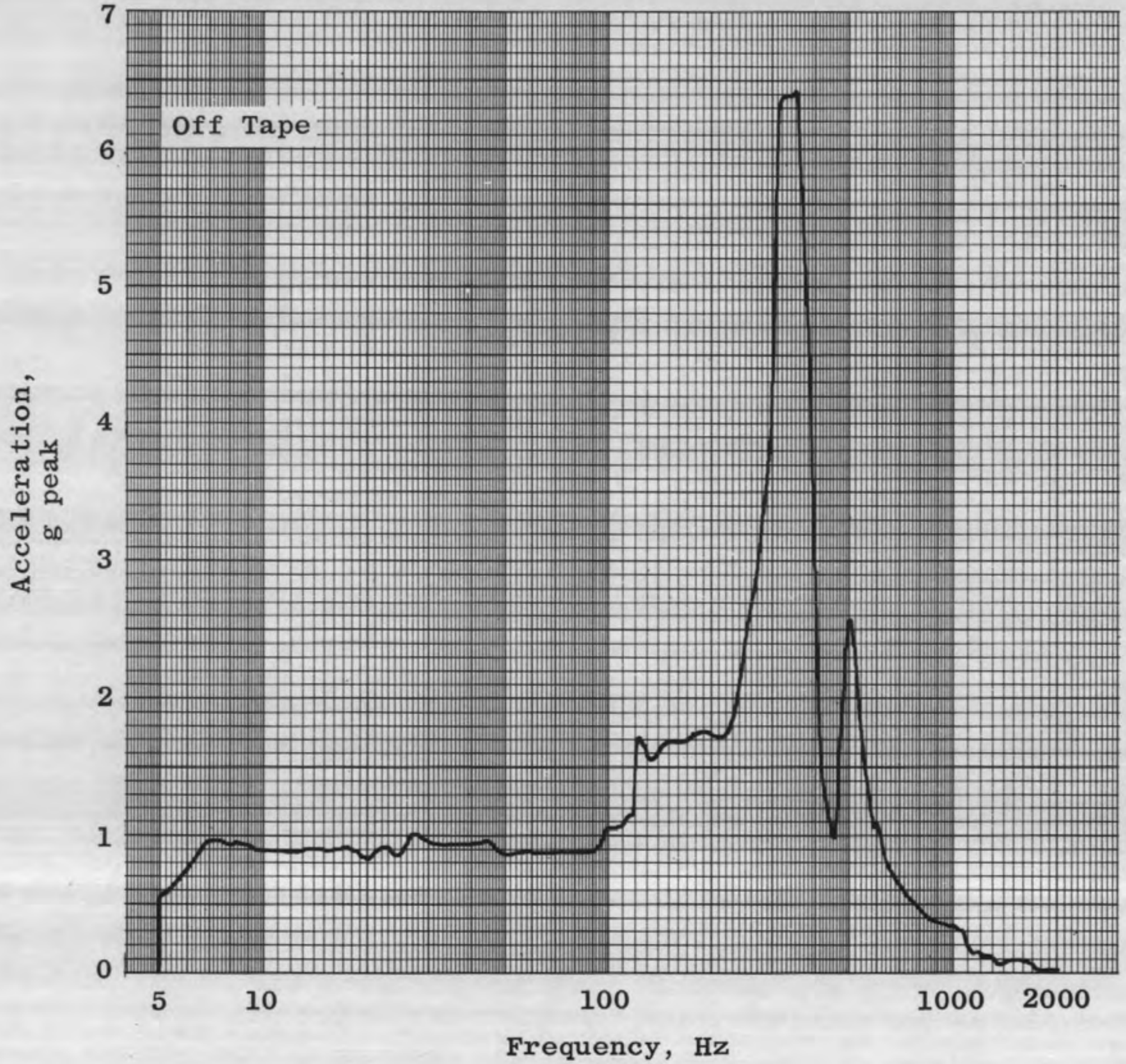
e. Accelerometer 3T
Figure 11. Continued.



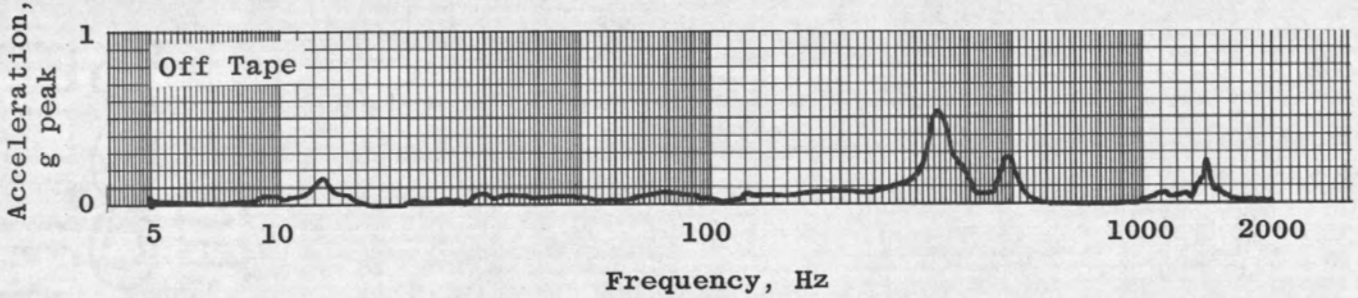
f. Accelerometer 3L
Figure 11. Continued.



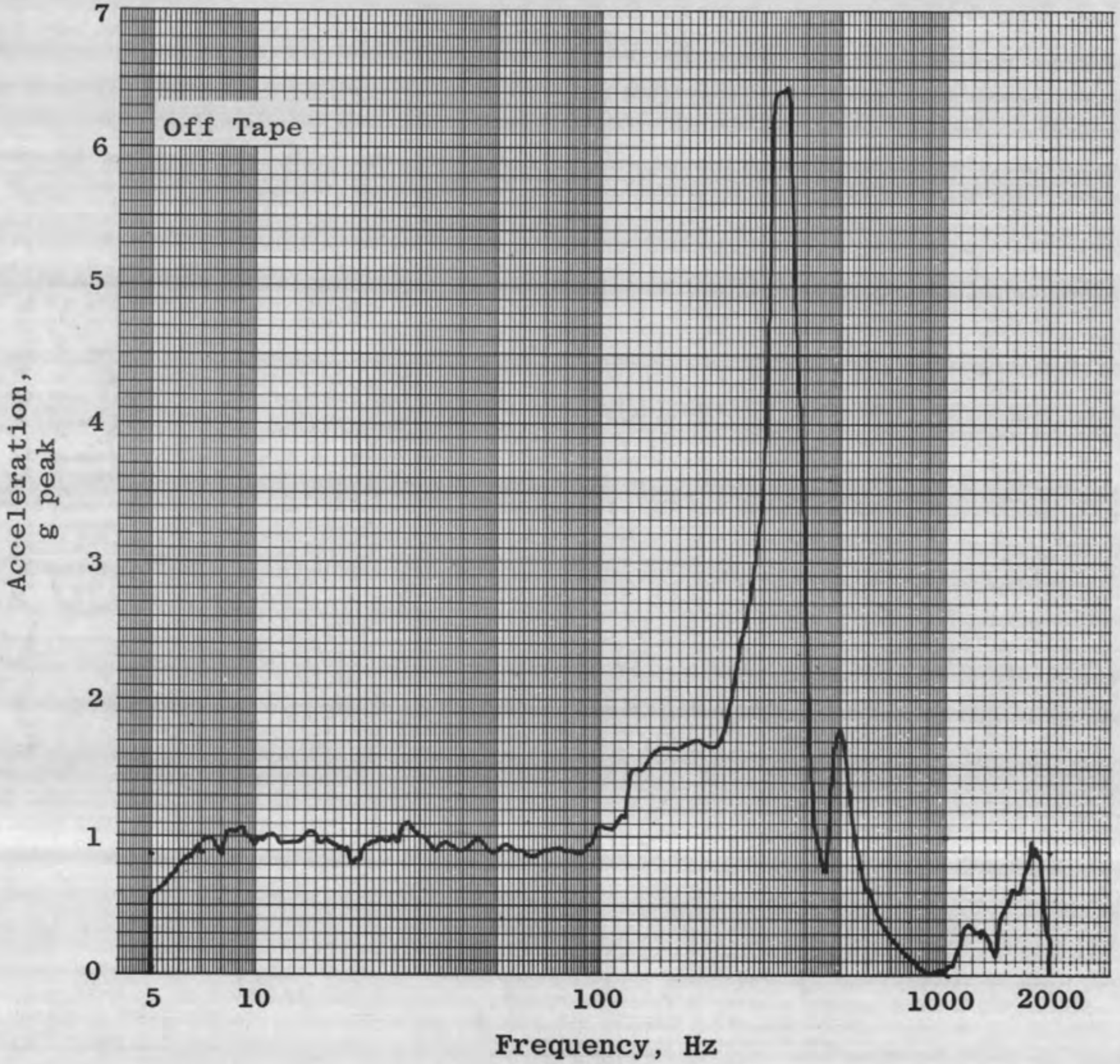
g. Accelerometer 3TR
Figure 11. Continued.



h. Accelerometer 4T
Figure 11. Continued.

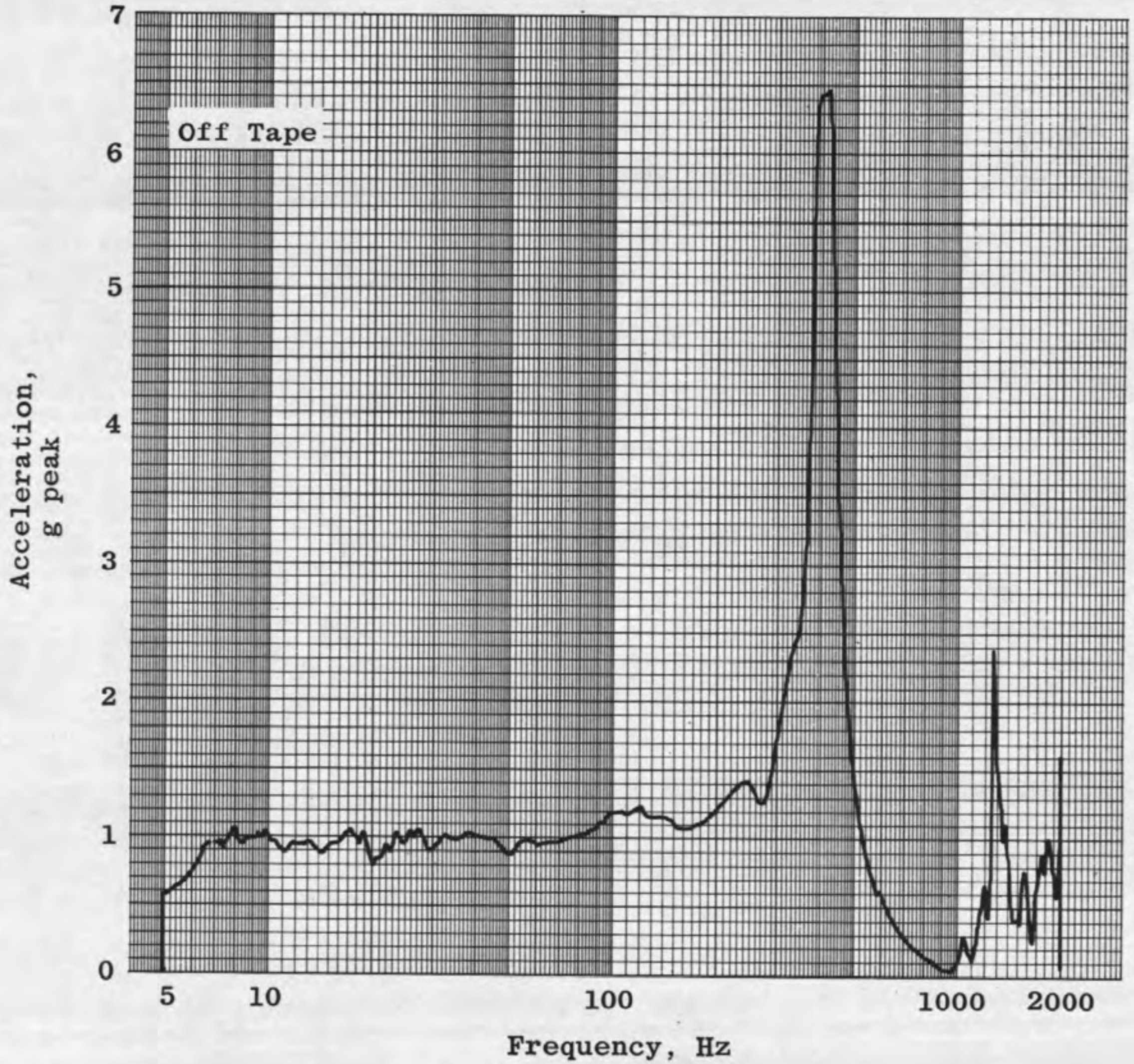


i. Accelerometer 4L
Figure 11. Continued.

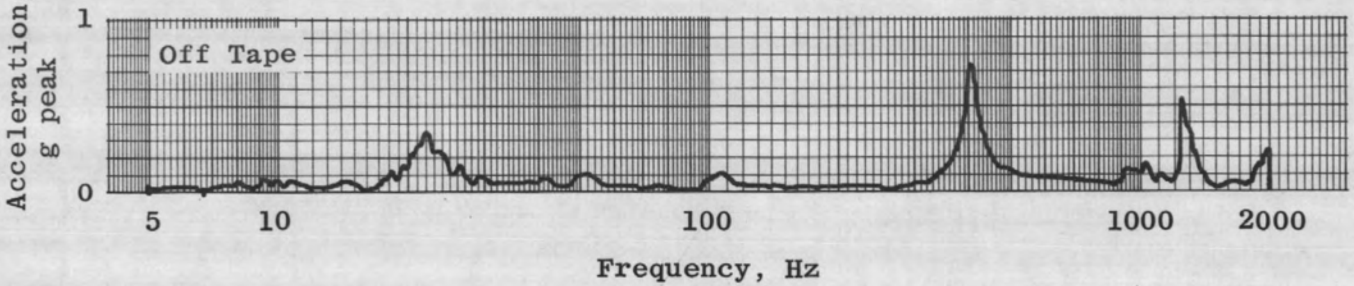


j. Accelerometer 5T

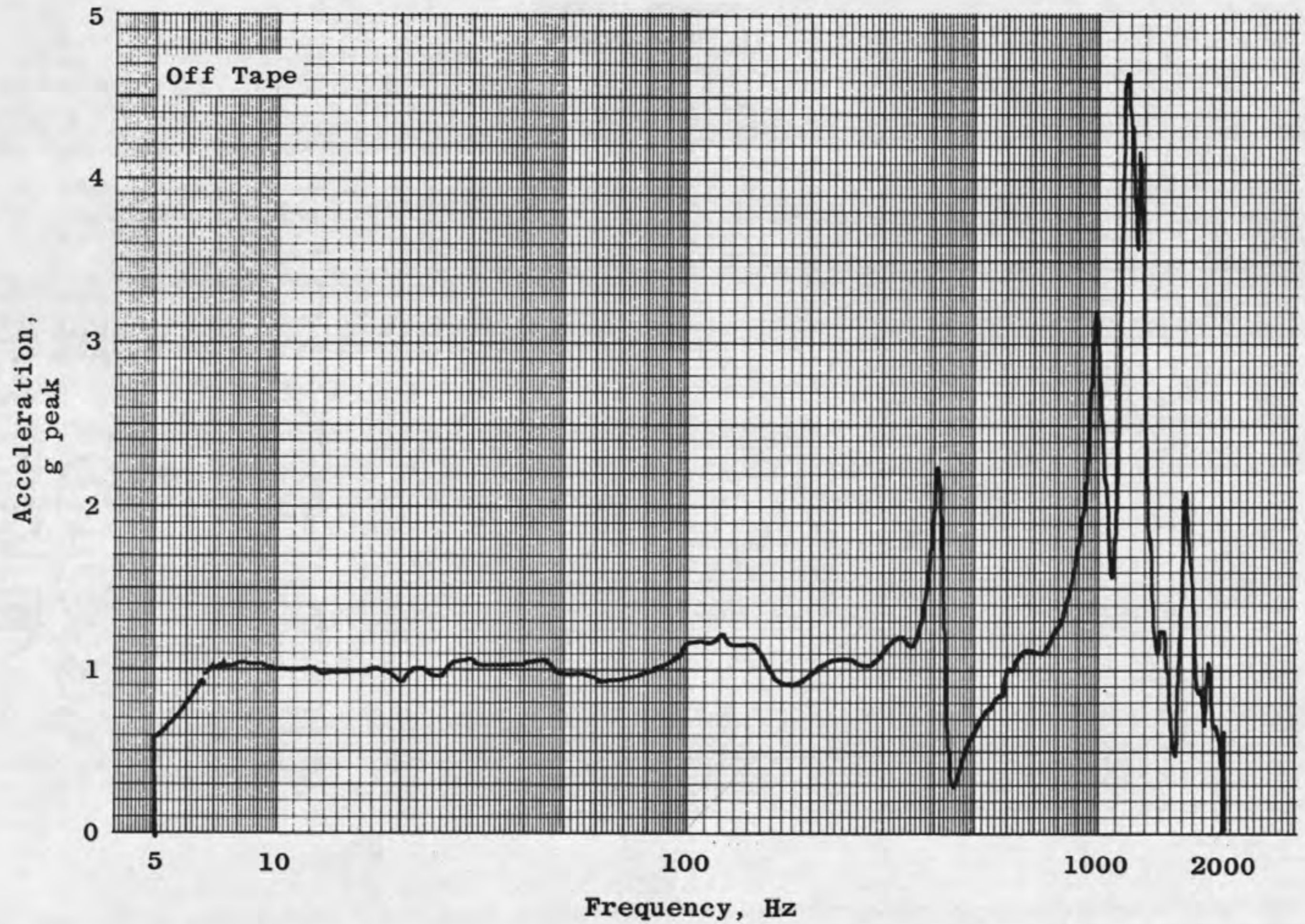
Figure 11. Continued.



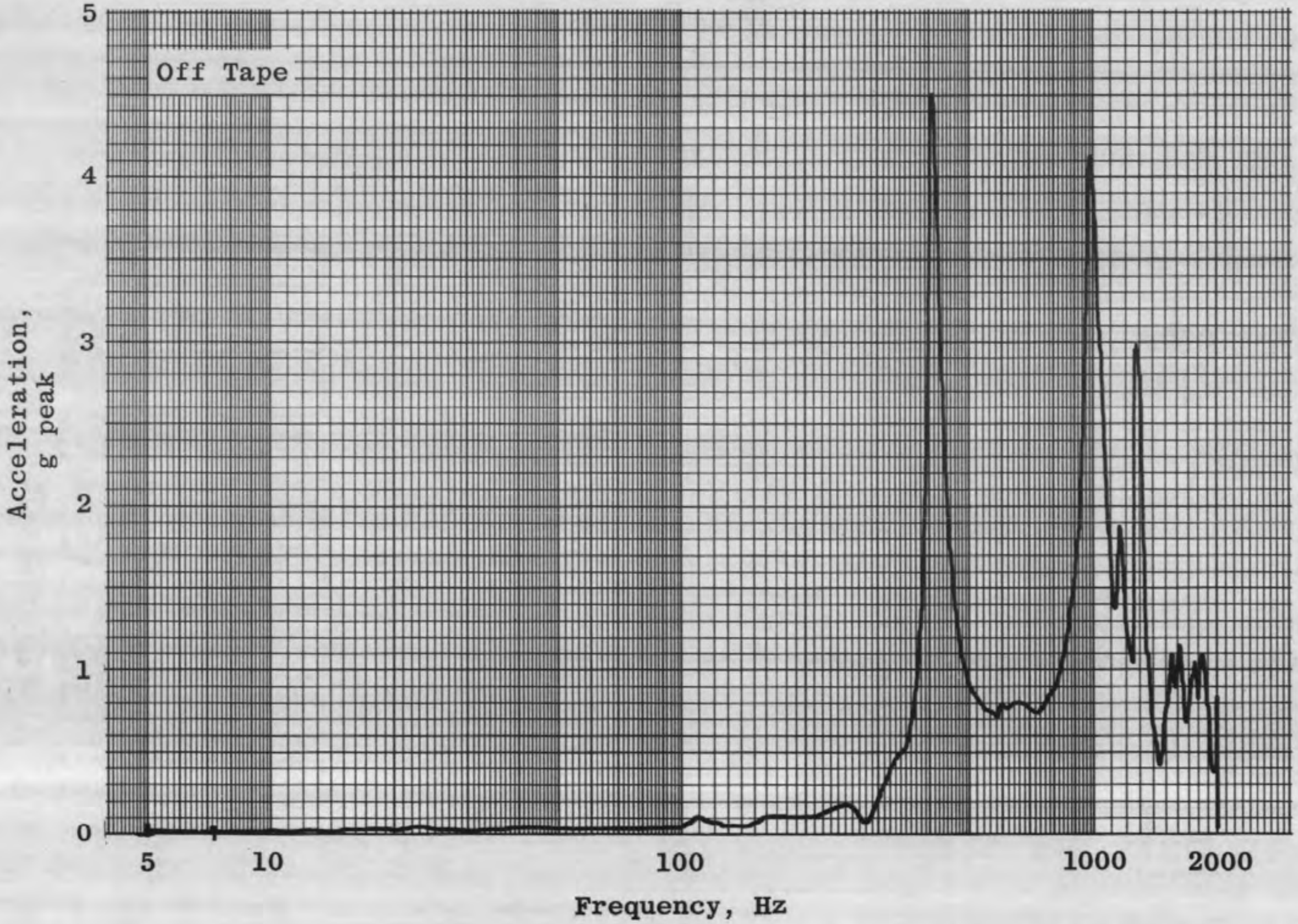
k. Accelerometer 6T
Figure 11. Continued.



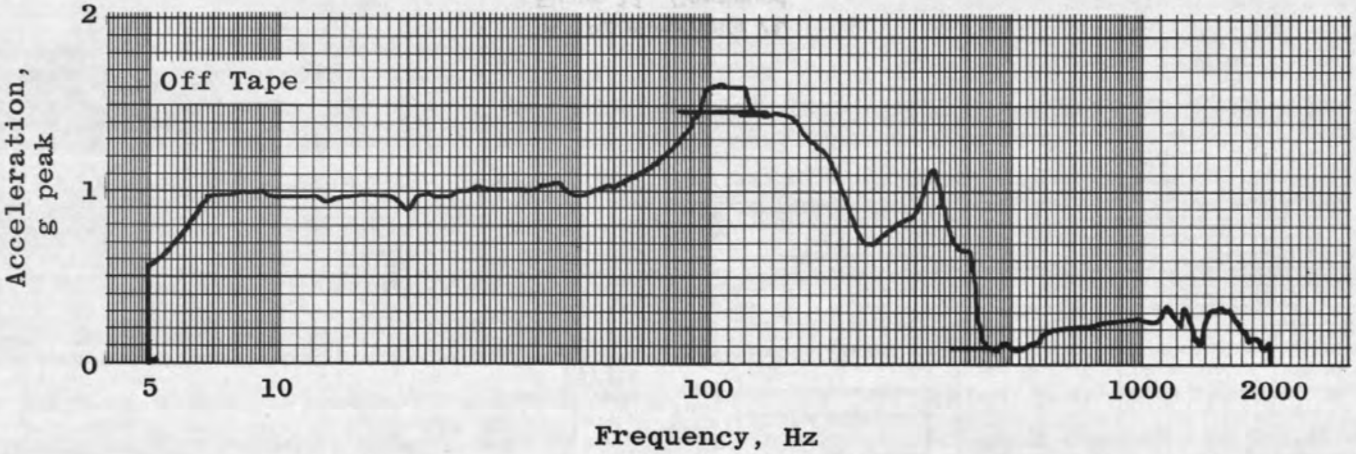
I. Accelerometer 6L
Figure 11. Continued.



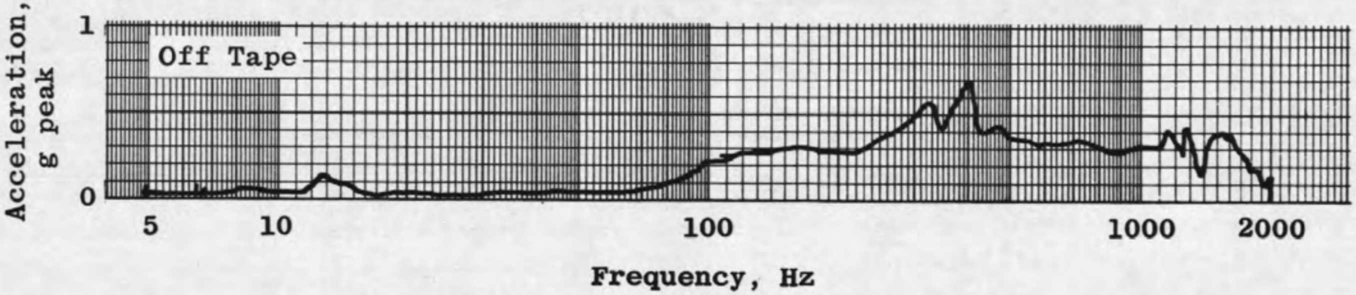
m. Accelerometer 7T
Figure 11. Continued.



n. Accelerometer 7L
Figure 11. Continued.



o. Accelerometer 8T
Figure 11. Continued.



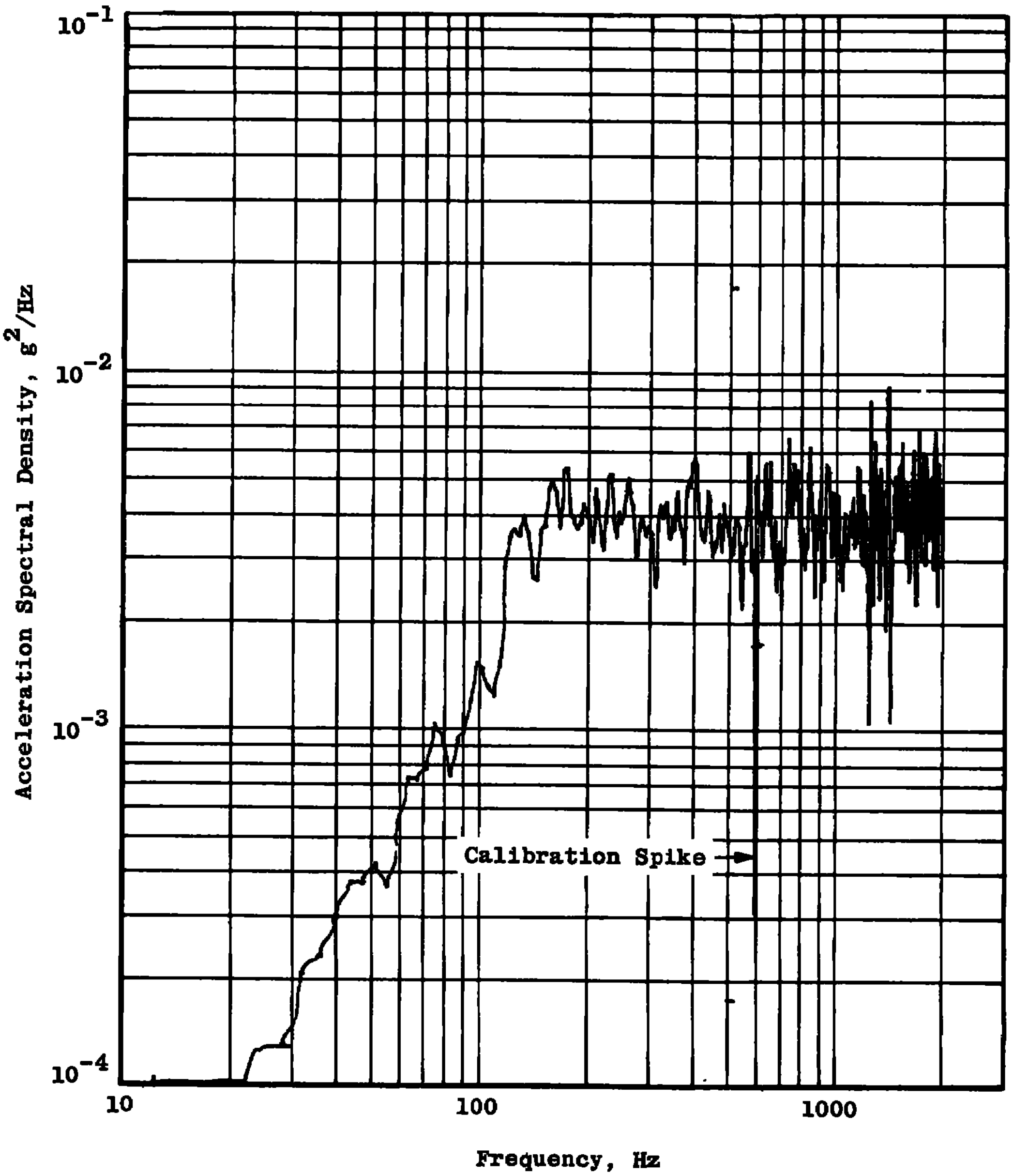
p. Accelerometer 8L
Figure 11. Concluded.

Run Time							
-20 db		-10 db		Full Power		Other_____	
min	sec	min	sec	min	sec	min	sec
			30		15		
			35		15		
			17	2	45		
			20				
			15				
			30				
			30				
			30				
			30				
			30				

Date: 1-13-76

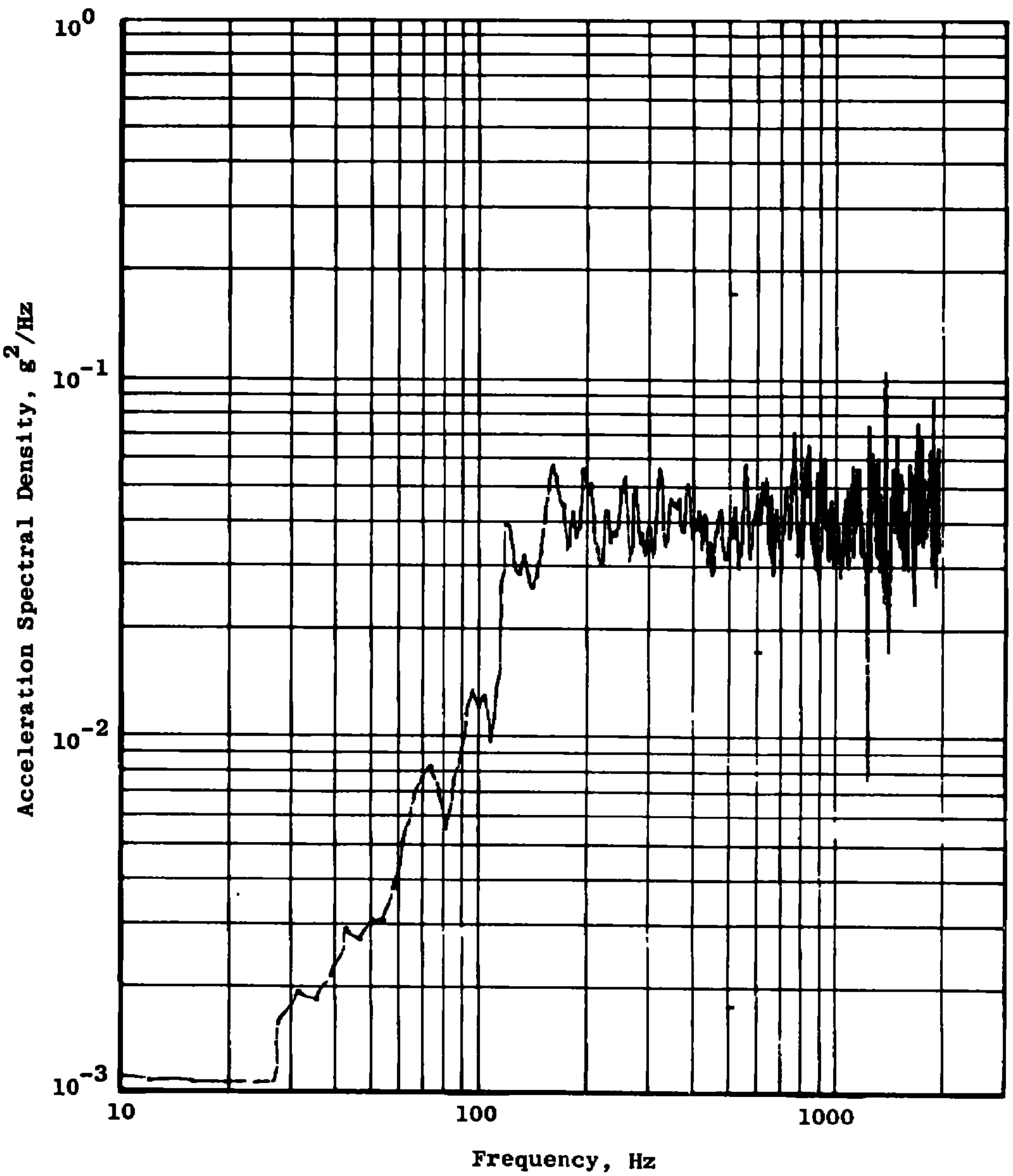
a. Run time log
Figure 12. Random vibration: thrust axis.

Vibration Level: 2.8 g rms
Analyzer: SD301D
Analyzer Bandwidth: 7.45 Hz
Accelerometer: 1T
Date: 1-13-77
Remarks: No. 1 15 sec at -10 db



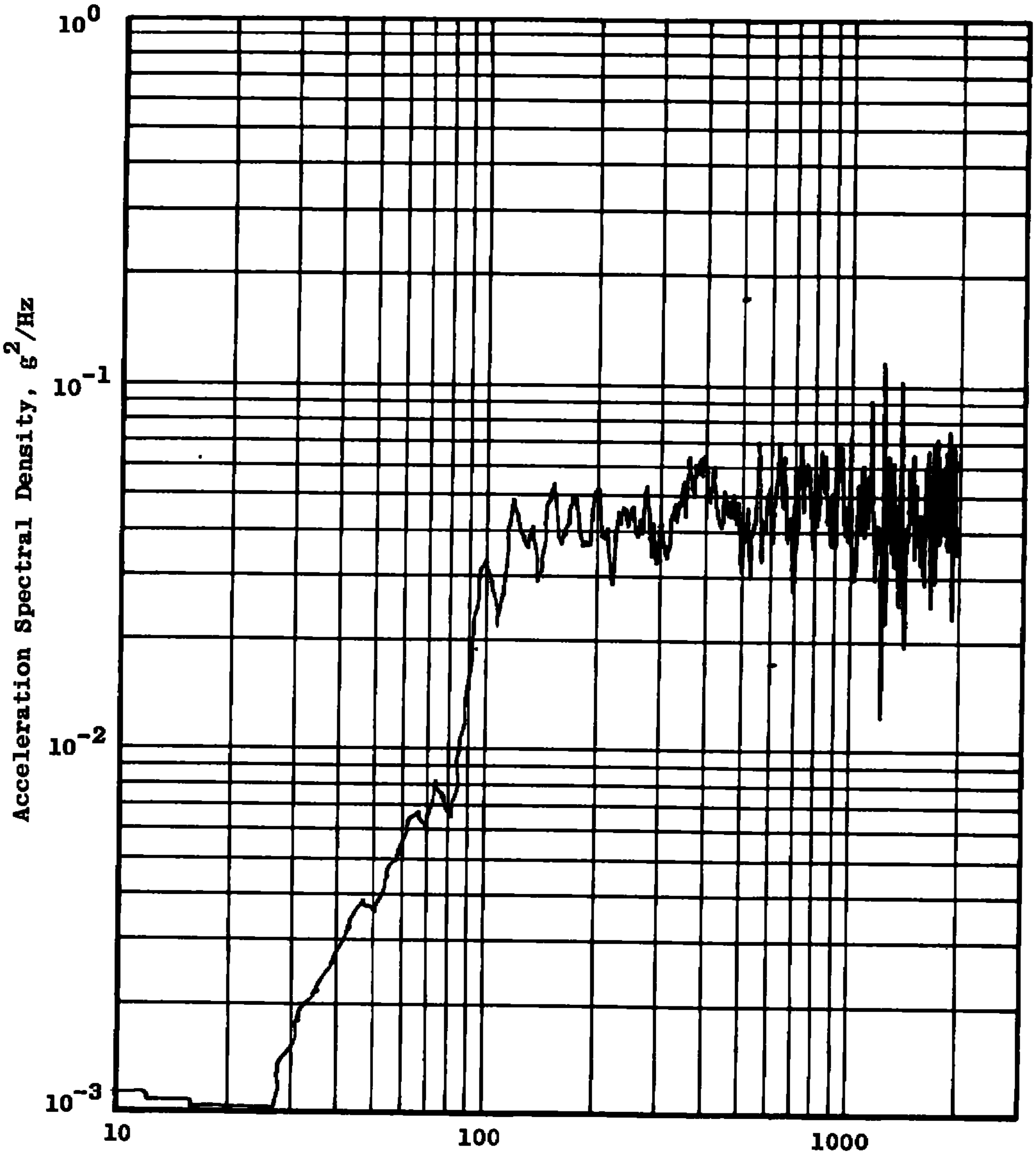
b. -10 db spectrum
Figure 12. Continued.

Vibration Level: 8.65 g rms
Analyzer: SD301D
Analyzer Bandwidth: 7.45 Hz
Accelerometer: 1T
Date: 1-13-77
Remarks: No. 1 15 sec at Full Power



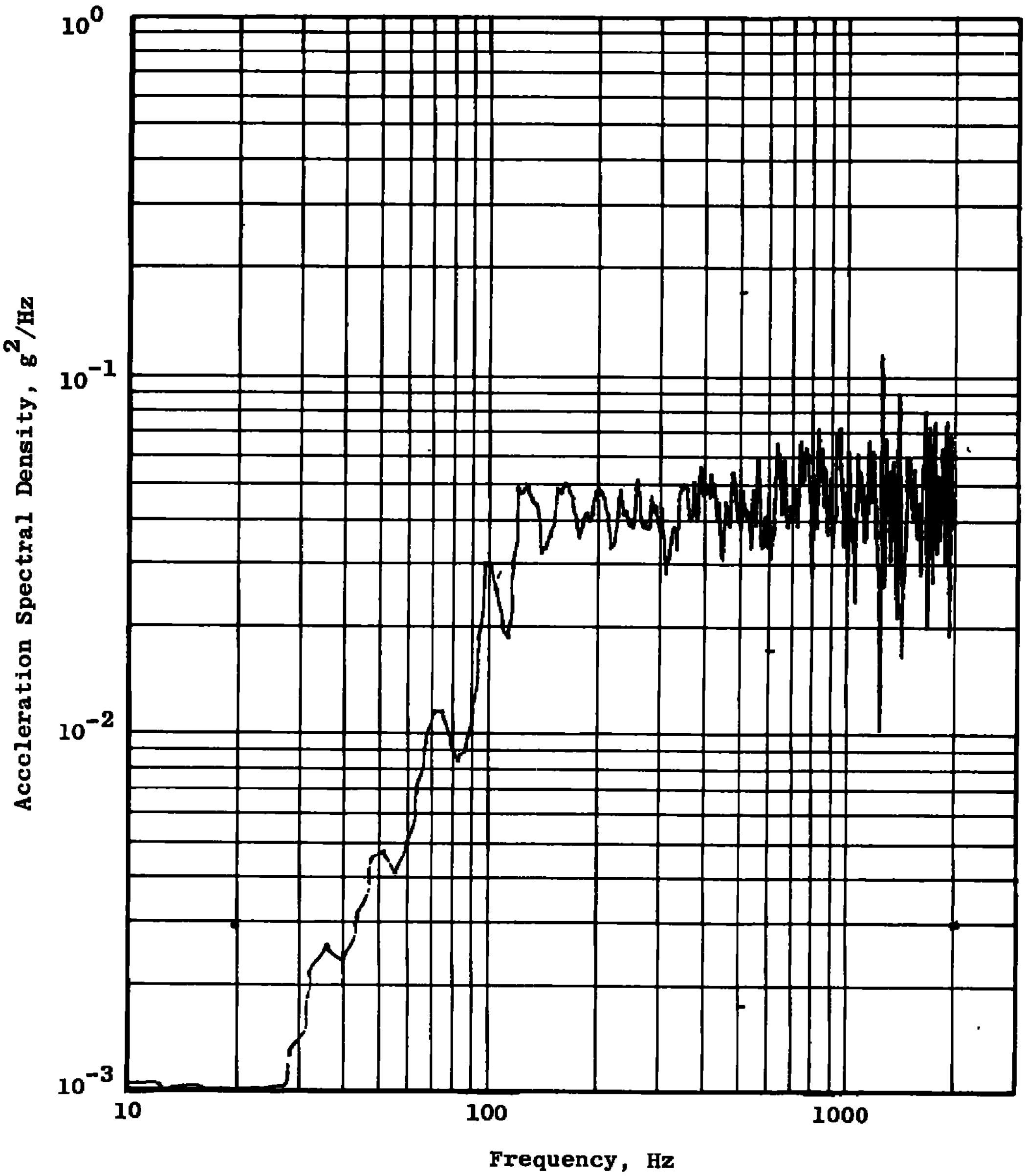
c. 15-sec equalization run No. 1 spectrum
Figure 12. Continued.

Vibration Level: 9.2 g rms
Analyzer: SD301D
Analyzer Bandwidth: 7.45 Hz
Accelerometer: 1T
Date: 1-13-77
Remarks: No. 2 15 sec at Full Power

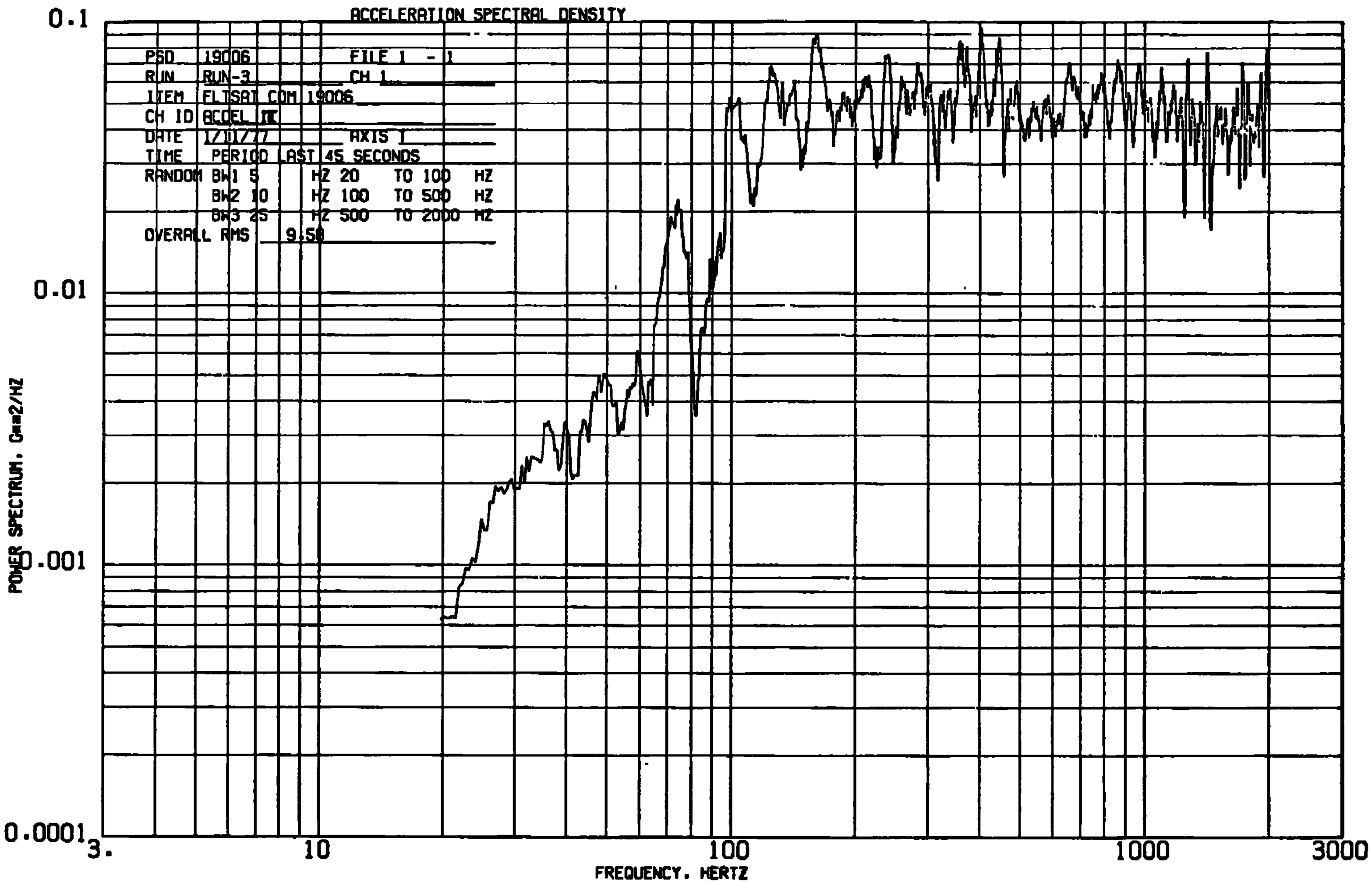


d. 15-sec equalization run No. 2 spectrum
Figure 12. Continued.

Vibration Level: 9.2 g rms
Analyzer: SD301D
Analyzer Bandwidth: 7.45 Hz
Accelerometer: 1T
Date: 1-13-77
Remarks: 2 min 45 sec at Full Power

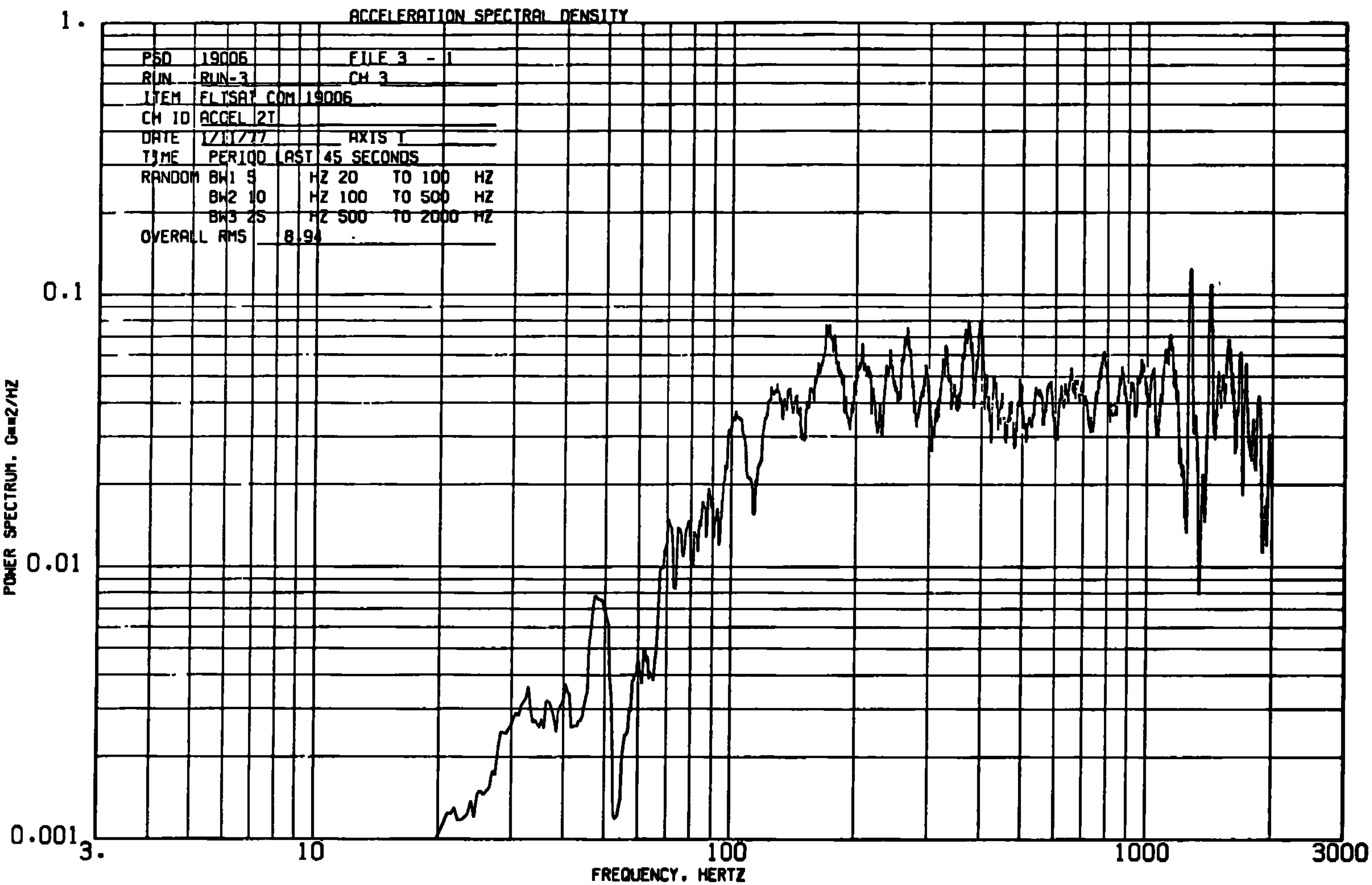


e. 2-min 45-sec run spectrum
Figure 12. Concluded.

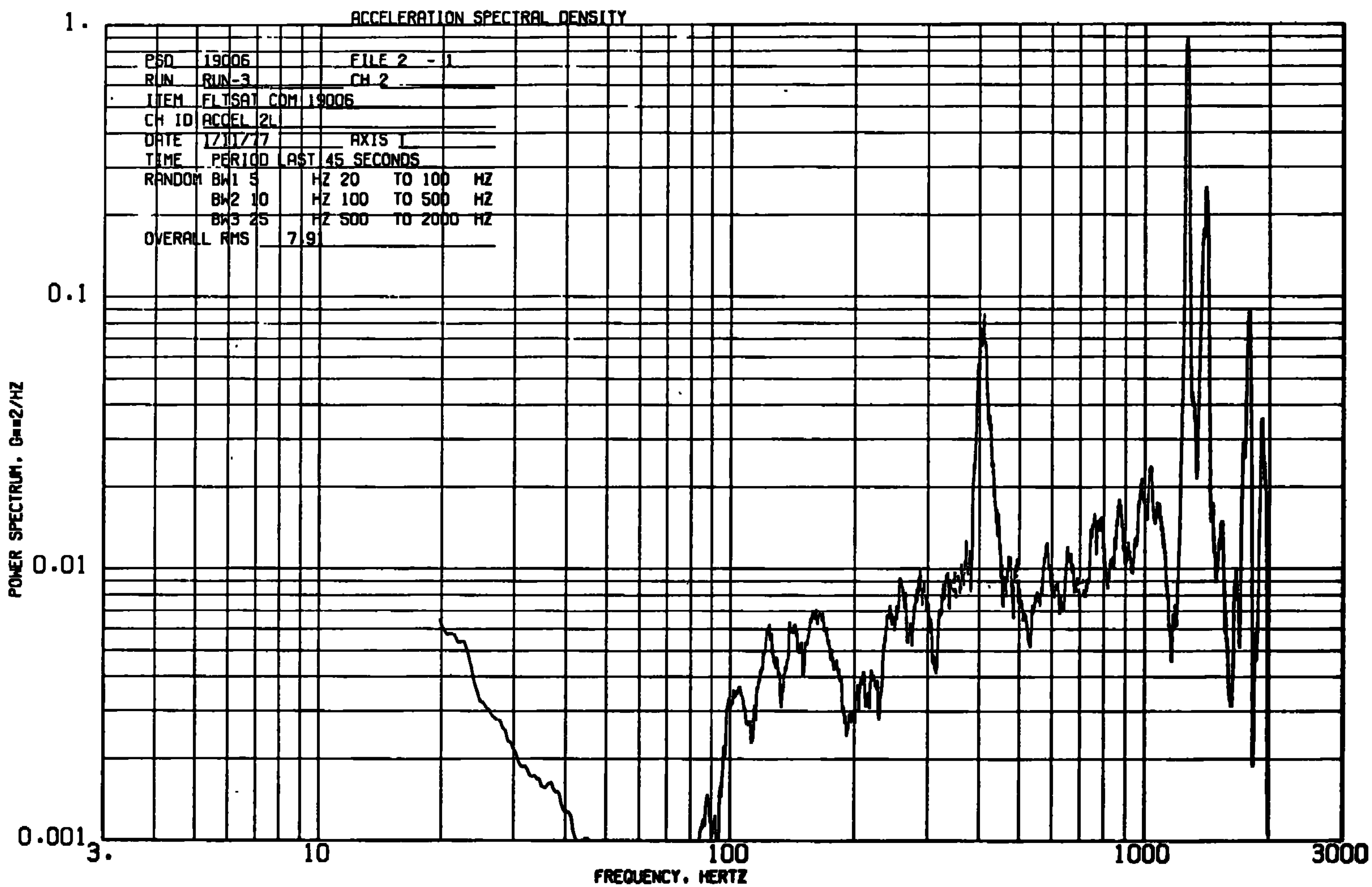


a. Accelerometer 1T (control)

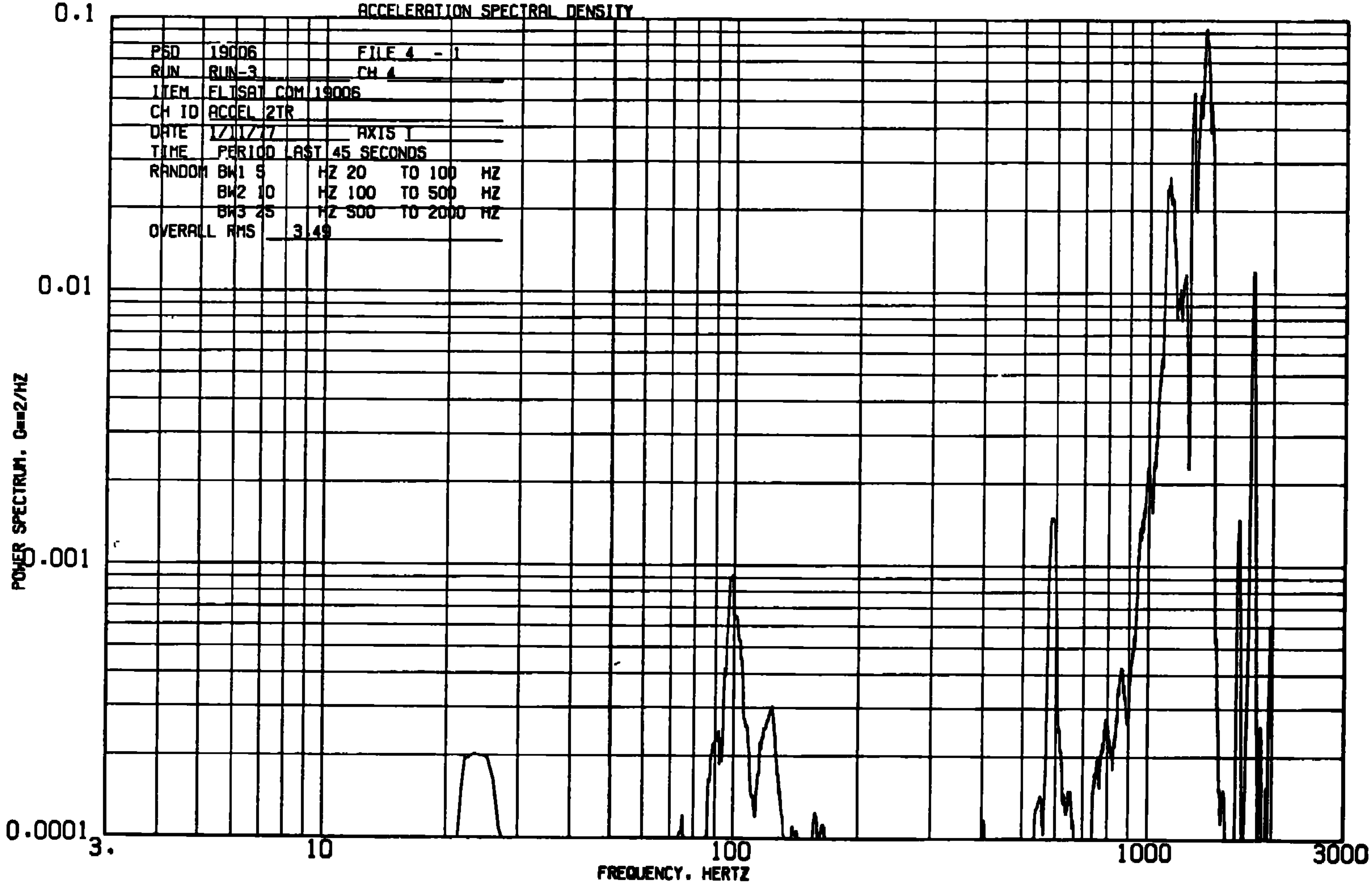
Figure 13. Random vibration: thrust axis - digital analysis.



b. Accelerometer 2T
Figure 13. Continued.

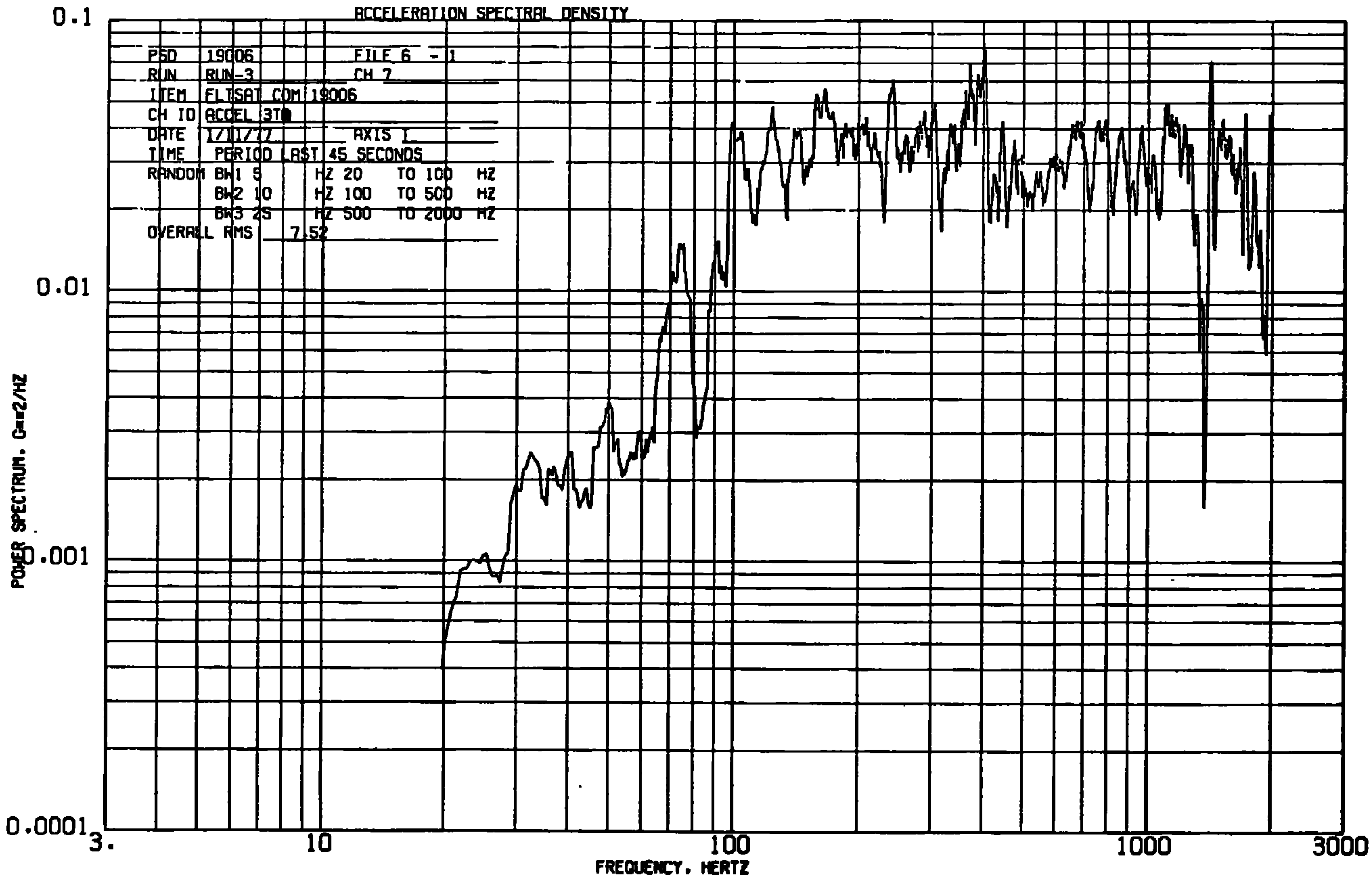


c. Accelerometer 2L
Figure 13. Continued.

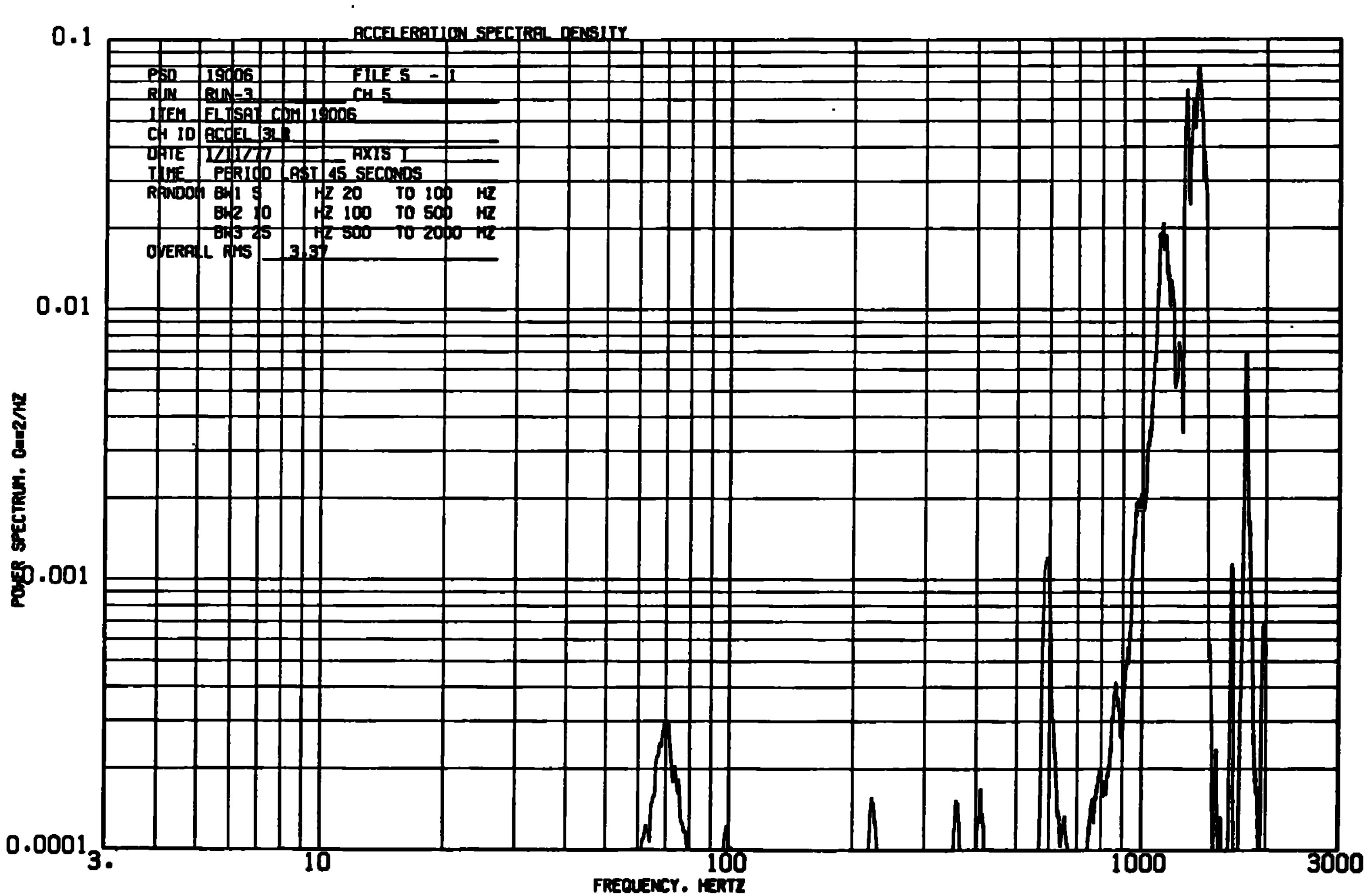


d. Accelerometer 2TR

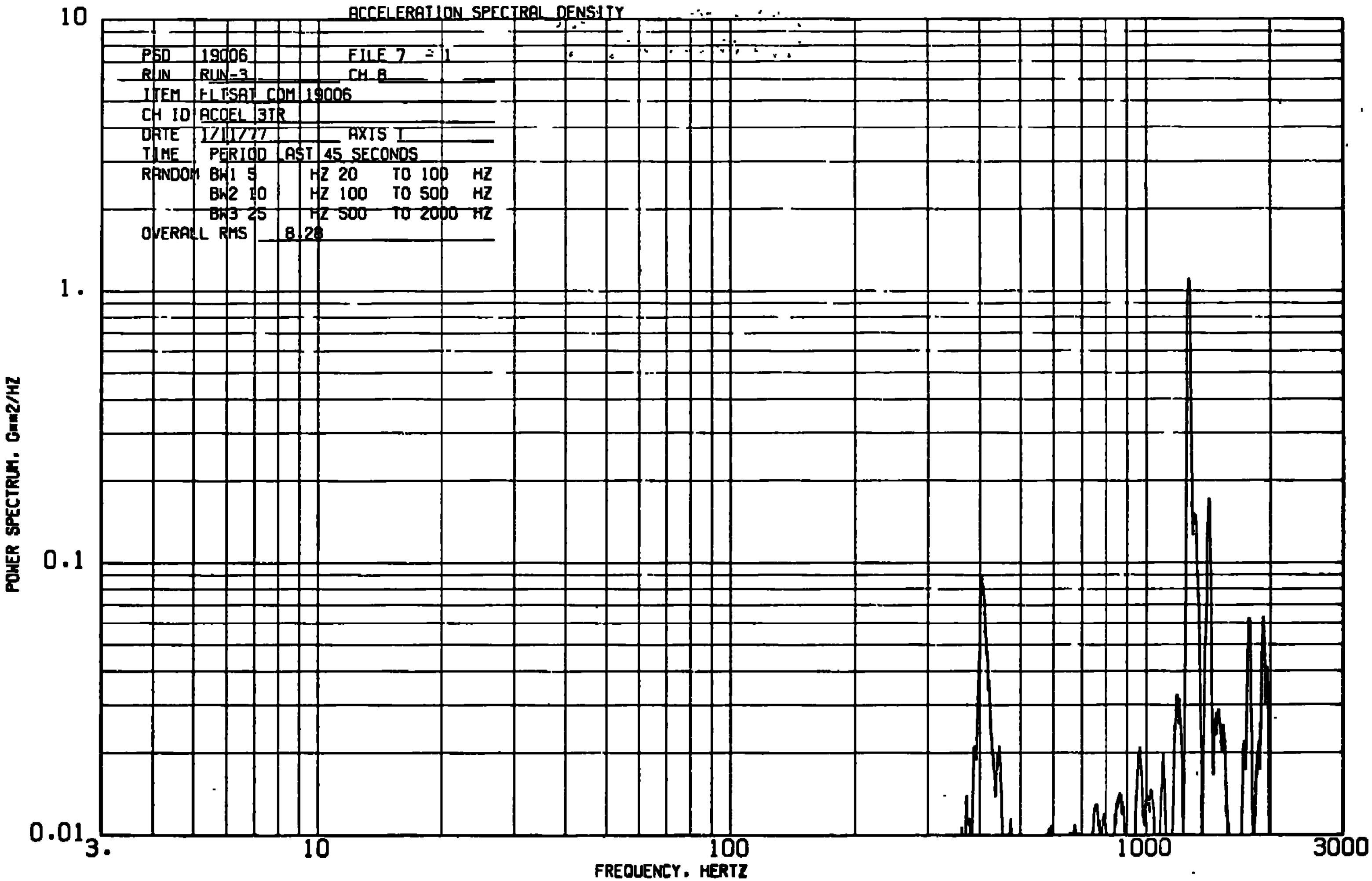
Figure 13. Continued.



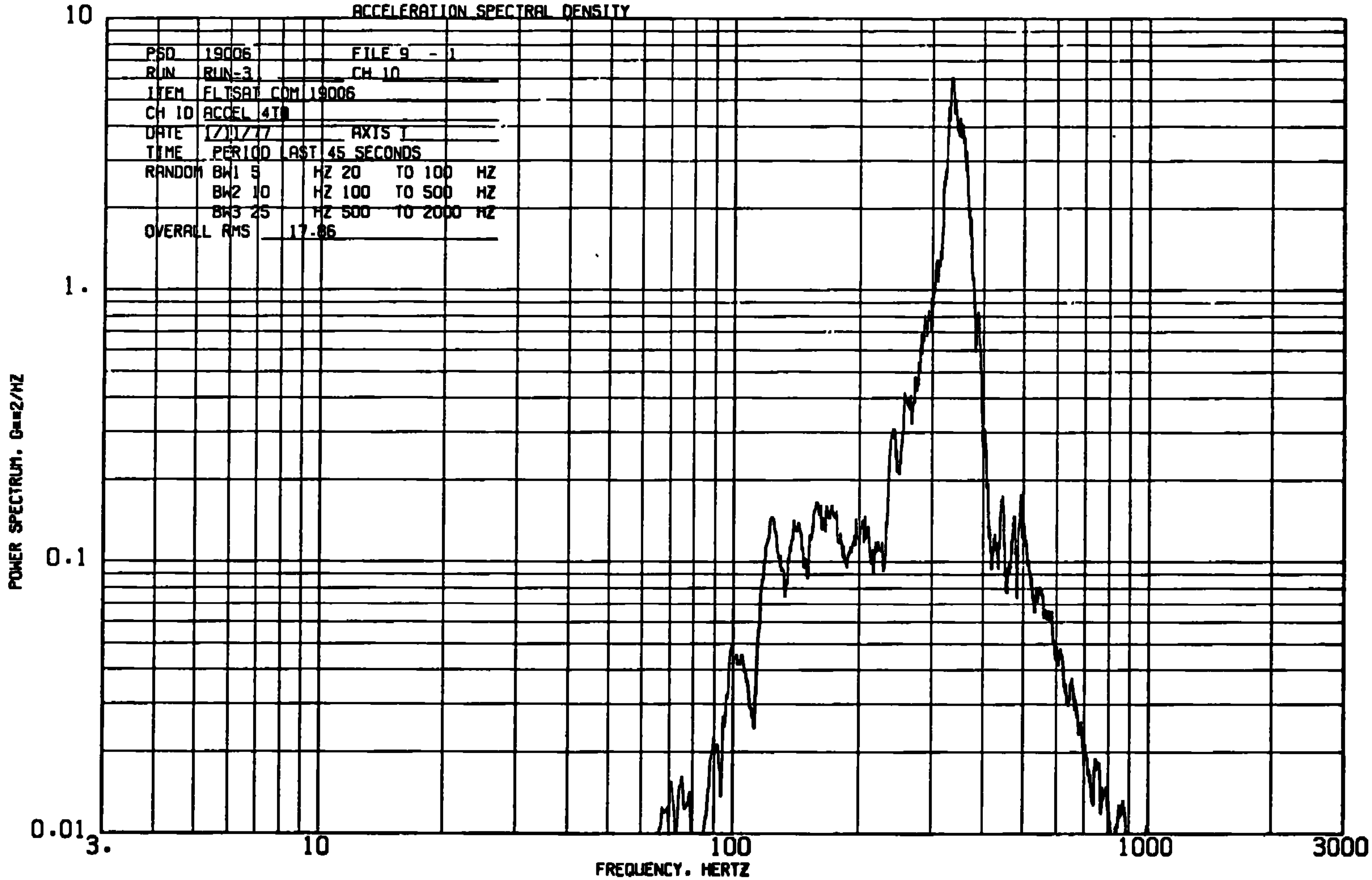
e. Accelerometer 3T
Figure 13. Continued.



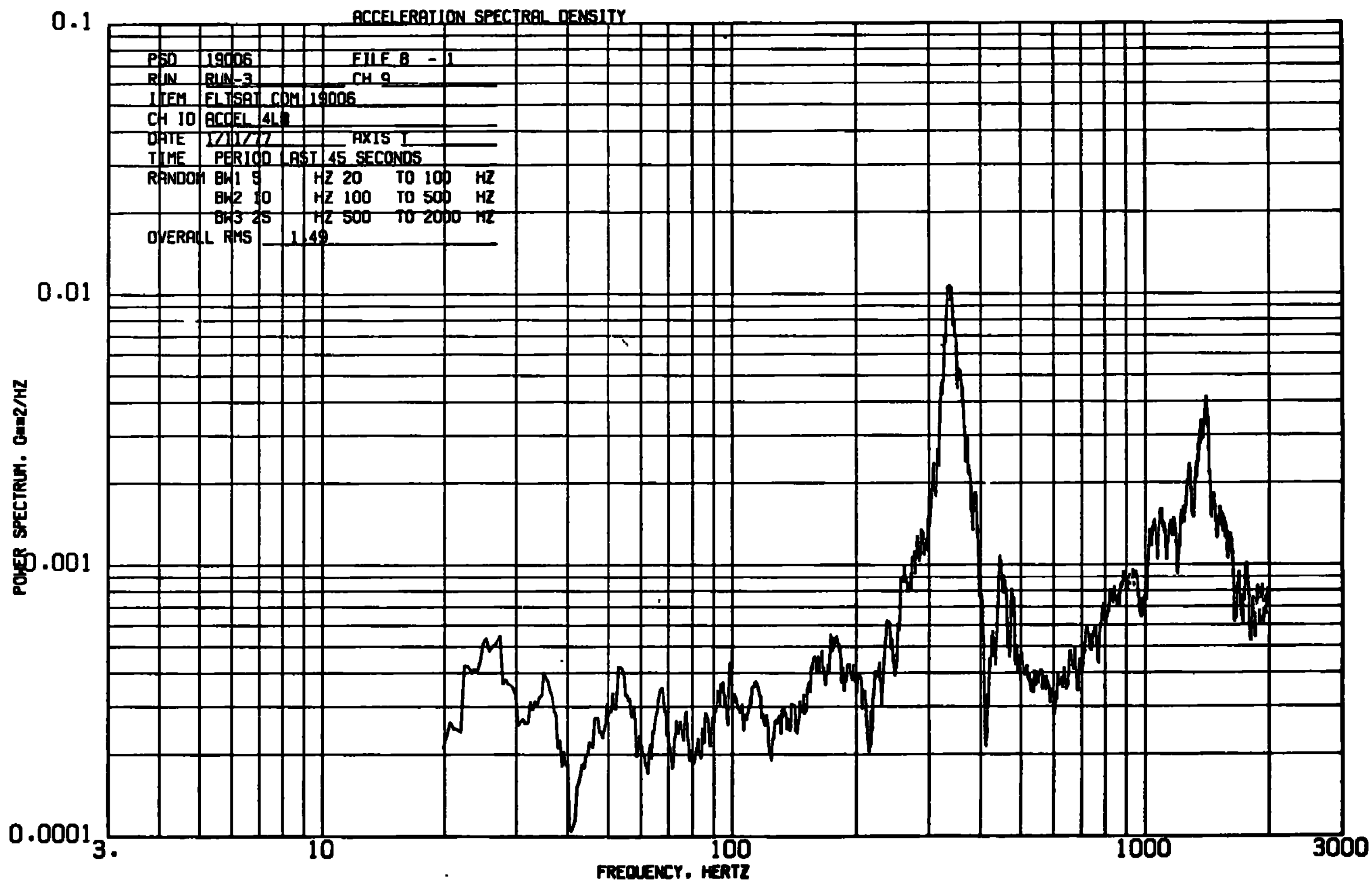
f. Accelerometer 3L
Figure 13. Continued.



g. Accelerometer 3TR
Figure 13. Continued.

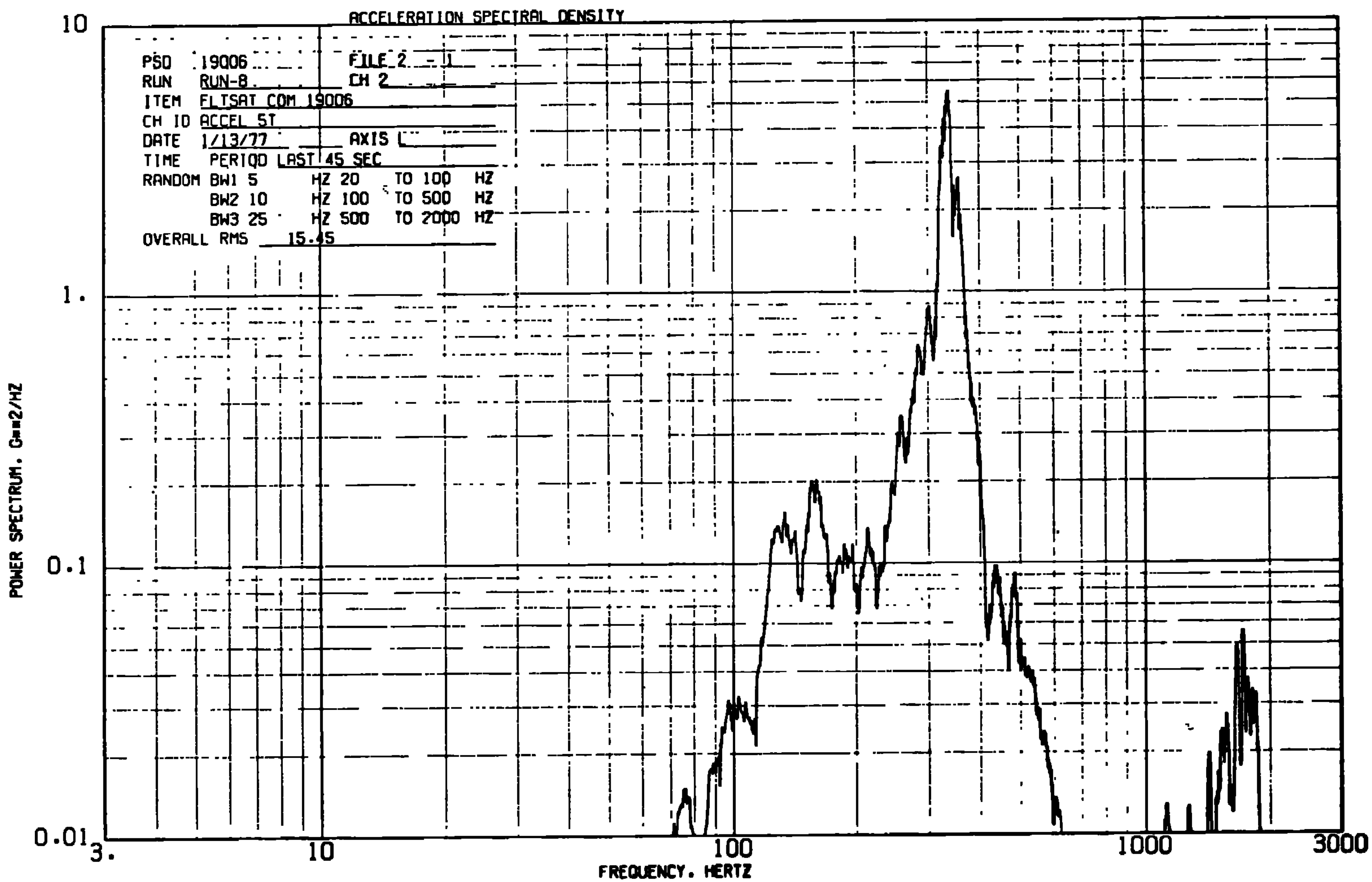


h. Accelerometer 4T
Figure 13. Continued.

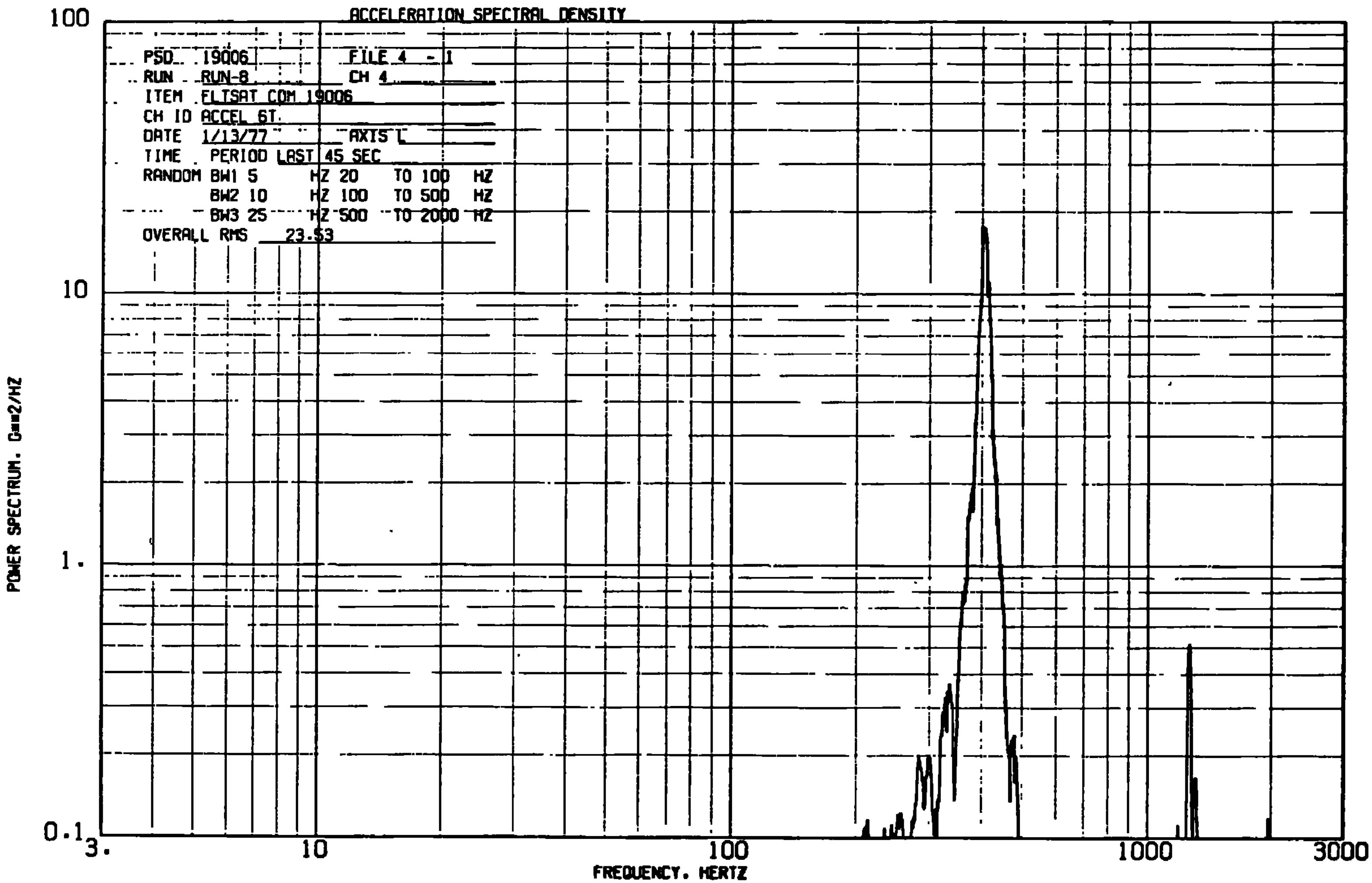


i. Accelerometer 4L

Figure 13. Continued.

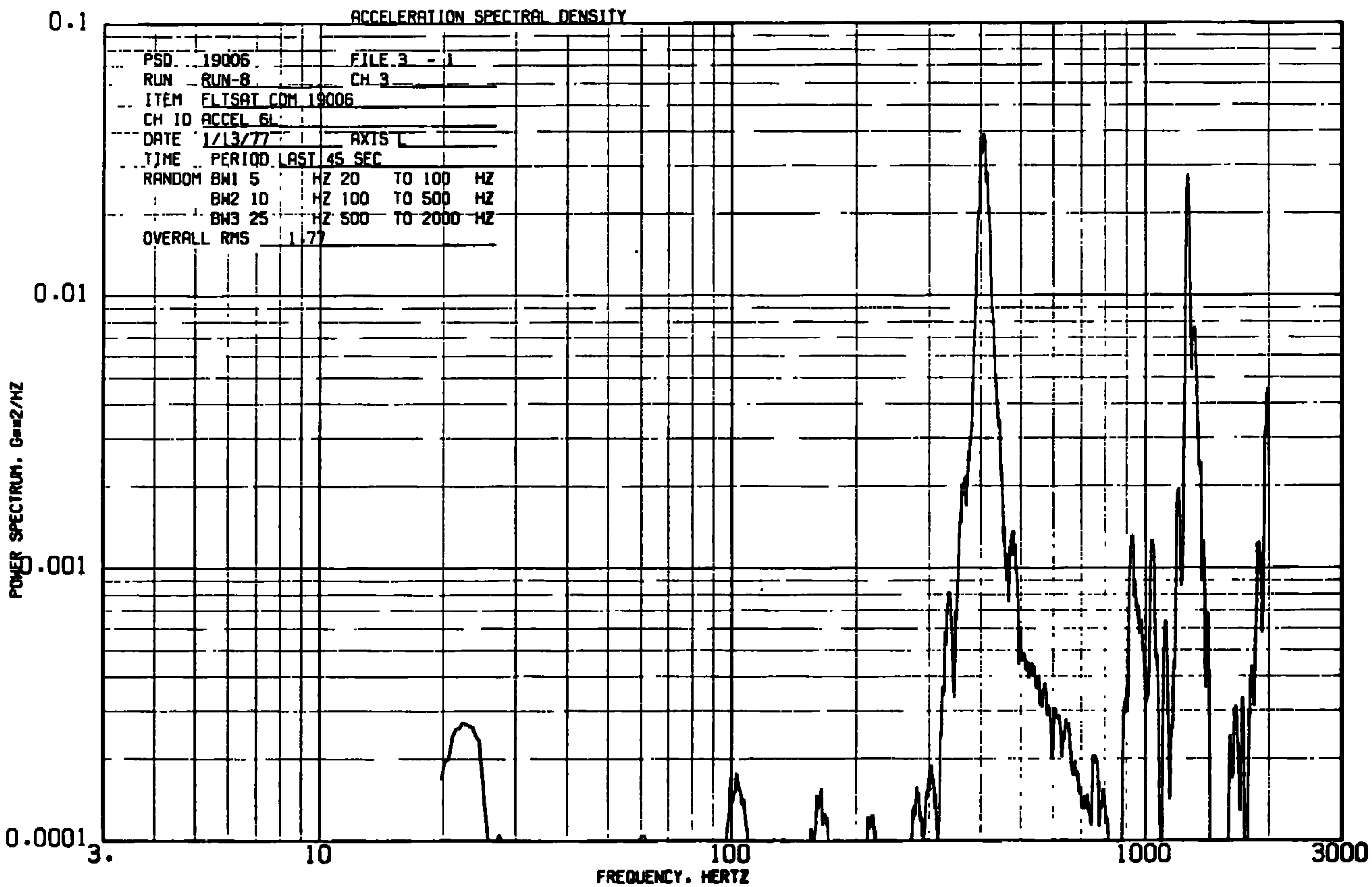


j. Accelerometer 5T
Figure 13. Continued.



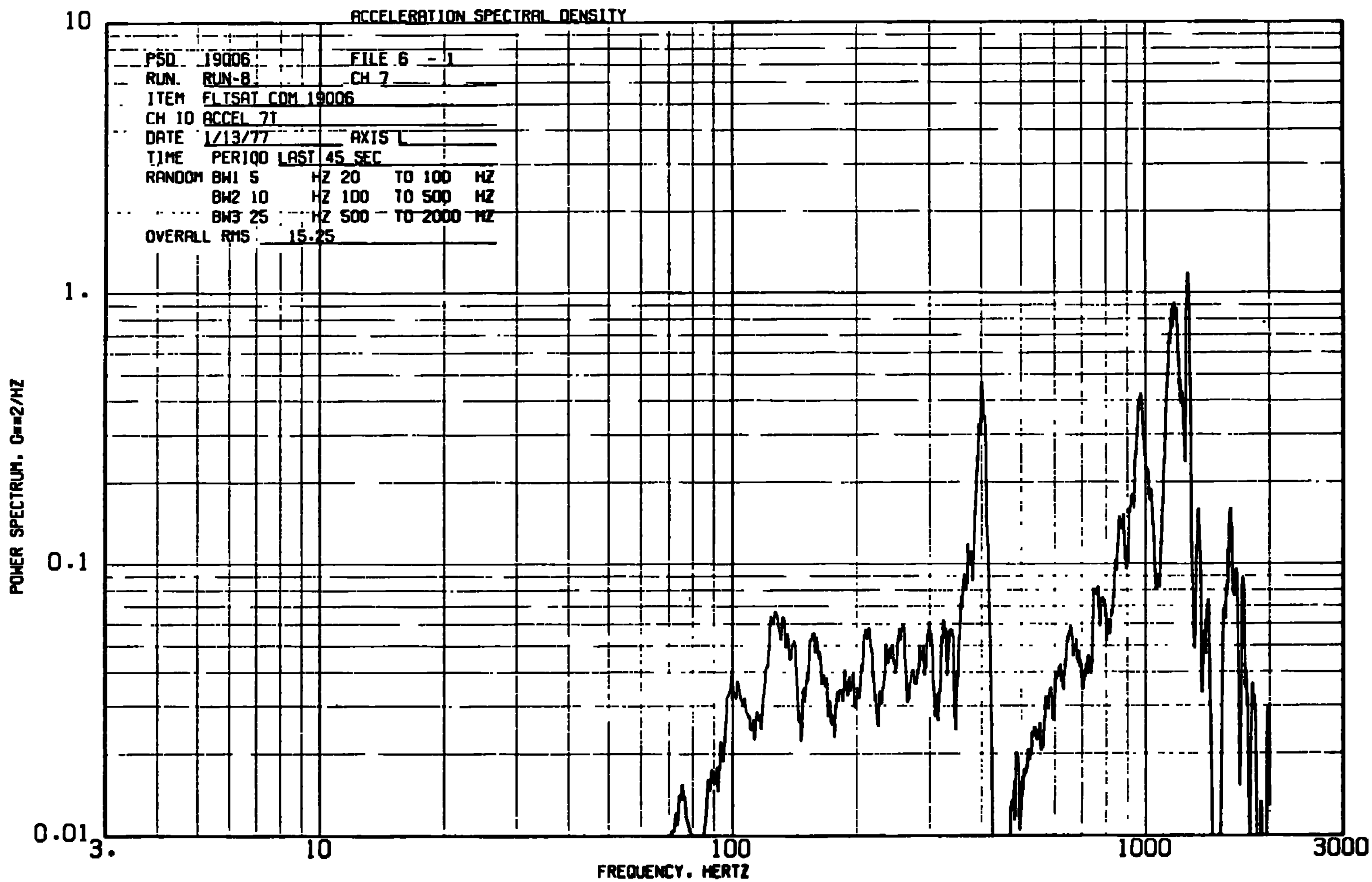
k. Accelerometer 6T

Figure 13. Continued.

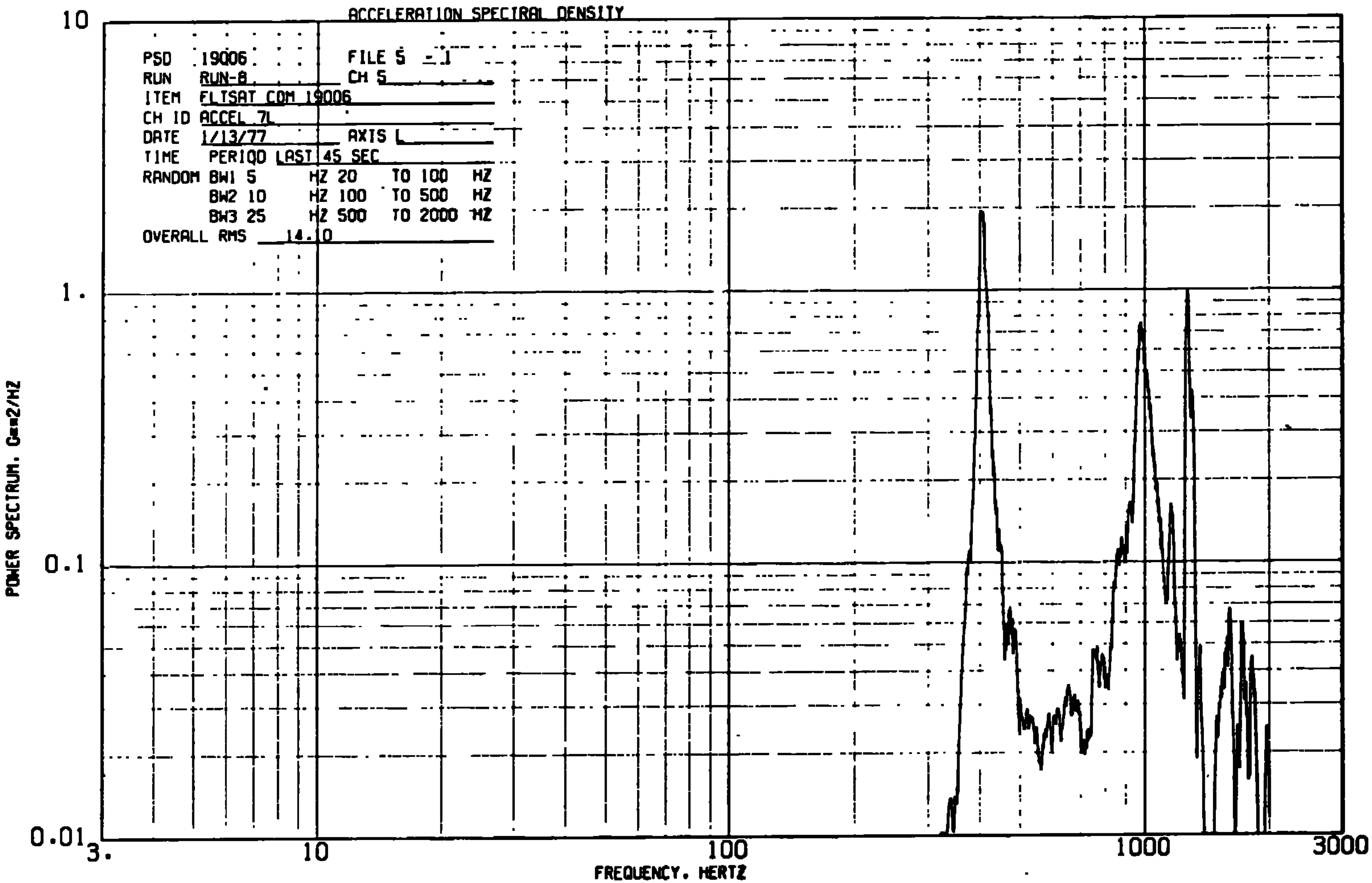


I. Accelerometer 6L

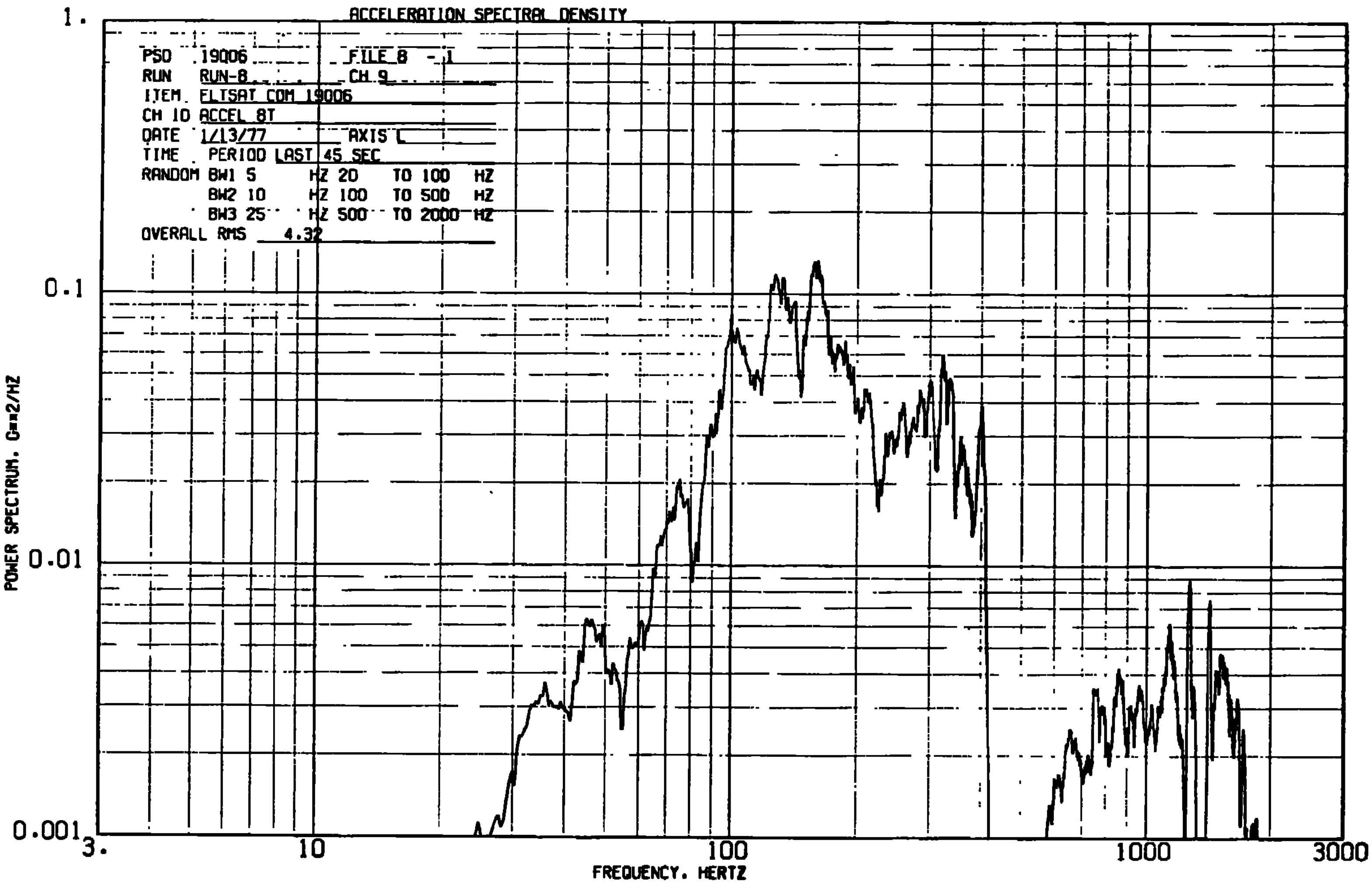
Figure 13. Continued.



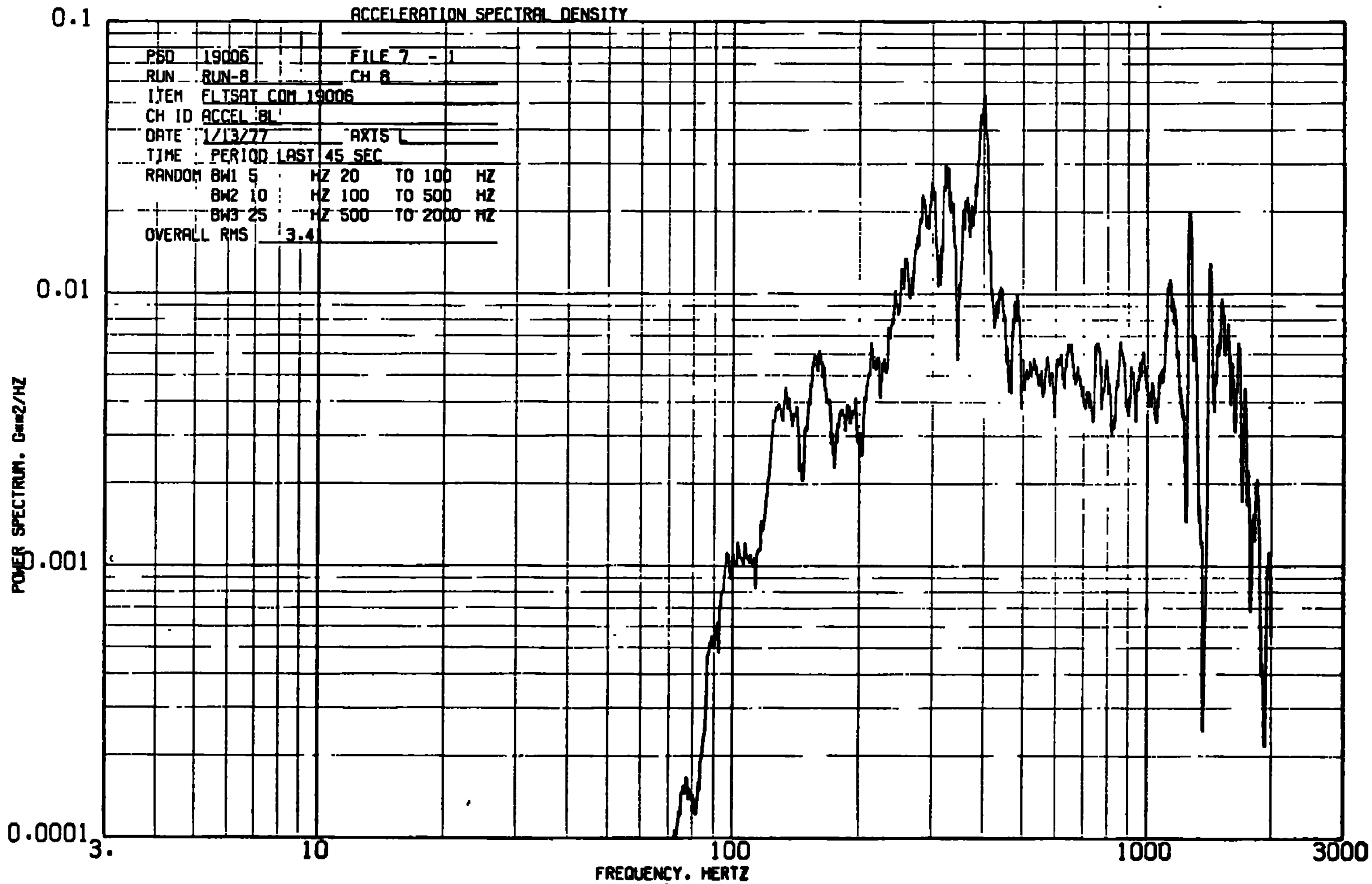
m. Accelerometer 7T
Figure 13. Continued.



n. Accelerometer 7L
Figure 13. Continued.



o. Accelerometer 8T
Figure 13. Continued.



p. Accelerometer 8L
Figure 13. Concluded.

Table 1. Instrumentation Calibration Traceability

Project No. V41T-26A; Test Title FLTSATCOM; Project Engineer R. E. Alt

Parameter Measured	Instrument Name	Instrument Number	Instrument Classification*	Calibration Interval	Date of Last Calibration
Acceleration	2228C Accelerometer	52520	T	As Req'd	Aug 1976
"	2228C Accelerometer	52549	T	"	"
"	2228C Accelerometer	52521	T	"	"
"	2228C Accelerometer	53863	T	"	"
"	2228C Accelerometer	52519	T	"	"
"	2228C Accelerometer	55250	T	"	"
"	2228C Accelerometer	52524	T	"	"
"	2228C Accelerometer	58817	T	"	"
"	2226C Accelerometer	53963	T	"	"
	SD309 Ensemble Averager	55355	T	"	Sept 1976
	SD301D Real Time Analyzer	55356	T	"	Sept 1976
	Model 13116 X-Y Display	55354	T	"	Sept 1976
	SD105C Amplitude Servo Monitor	P/N 602198	T	"	July 1976
	SD1012B Tracking filter	54899	T	"	Aug 1976
	SD104A-2 Sweep Oscill.	54898	T	"	July 1976
	SD1010B Carrier Generator	54897	T	"	Aug 1976
	Fluke 8375A Digital Multimeter	55155	S	6 mo.	Oct 1976
Acceleration	Unholtz Dickie Charge Amplifier	52624	T	As Req'd	Nov 1976
"	"	53889	T	"	"
"	"	58302	T	"	"
"	"	58220	T	"	"
"	"	58201	T	"	"
"	"	53890	T	"	"
"	"	58221	T	"	"
"	"	52719	T	"	"
"	"	52626	T	"	"
"	"	52622	T	"	"
"	"	52621	T	"	"

* S = Working Standard
T = Test Instrumentation Equipment

Table 1. Concluded.

Parameter Measured	Instrument Name	Instrument Number	Instrument Classification*	Calibration Interval	Date of Last Calibration
Acceleration	Unholtz Dickie Charge Amplifier	52625	T	As Req'd	Nov 1976
"	"	54094	T	"	"
"	"	52615	T	"	"
"	"	52616	T	"	"
"	"	52617	T	"	"
"	"	52618	T	"	"
Acceleration Levels	Honeywell 1858 CRT Visicorder	55386	T	"	Dec 1976
"	Model 1060 RMS Voltmeter	49735	T	"	Nov 1976
"	Thermo Systems 1060 RMS Voltmeter	49737	T	"	"
"	Spectral Density Voltmeter	40174	S	5 mo.	"
Acceleration Level Recorder	VR3700B Tape Recorder	53536	T	---	---
"	"	57884	T	---	---
	ASDE-80 Equalizer Anal.	38871	T	---	---
Safety Circuit Levels	SD129A Signal Vibration Protector	58667	T	As Req'd	Aug 1976
	Fluke 8375A Digital Multimeter	55154	S	6 mo.	Oct 1976

* S = Working Standard
  T = Test Instrumentation Equipment

Table 2. Summary of Test Activity

Date	Activity or Item Performed	Time	Building Temp., °F
Jan 5	Lateral axis fixture installation	0600	71
		1200	71
	FLTSATCOM motor received and inspected	1800	70
		2400	69
Jan 6	Dynamics ring installed on motor flange	1200	68
		1800	65
	Accelerometer Installation started	2400	68
Jan 7	Accelerometer installation and checkout continued	0600	68
		1200	65
	Motor installed on lateral axis test fixture	1800	62
		2400	67
Jan 8	No activity	0600	68
		1200	68
		1800	68
		2400	67
Jan 9	No activity	0600	66
		1200	68
	Temperature control of building poor because of ambient temperature conditions	1800	54
Jan 10	Lateral axis test installation completed and	0600	59
	instrumentation checkout conducted	1200	58
		1800	58
		2400	
Jan 11	Lateral axis sine test conducted	0600	58
		1200	71
	Lateral axis random test conducted	1800	70
		2400	69
Jan 12	Motor removed from lateral	0600	71
	axis fixture and installed on thrust	1200	72
	axis fixture	1800	70
	Thrust axis sine test conducted	2400	72

Table 2. Concluded.

Date	Avtivity or Item Performed	Time	Building Temp., °F
Jan 13		0600	74
	Thrust axis random test conducted	1200	72
	Motor removed from thrust axis	1800	71
	fixture, dynamics ring removed and handling ring installed	2400	72
Jan 14		0600	71
	Motor installed in transportation container	1200	72
		1800	72
	Test data plotted	2400	70
Jan 15	No activity	0600	68
		1200	68
		1800	70
		2400	69
Jan 16	No activity	0600	68
		1200	69
		1800	70
		2400	69
Jan 17	Motor transferred to X-ray laboratory	0600	68
		1200	68
	Test data plotted		

Table 3. Random Vibration RMS Acceleration Levels.

Lateral Axis (L)		Thrust Axis (T)	
Accelerometer Designation	RMS g-level	Accelerometer Designation	RMS g-level
1L	9.64	1T	9.58
2L	12.66	2T	8.94
2T	11.61	2L	7.91
2TR	5.43	2TR	3.49
3L	5.38	3T	7.52
3T	8.23	3L	3.37
3TR	13.07	3TR	8.28
4L	5.95	4T	17.86
4T	6.44	4L	1.49
5T	5.93	5T	15.45
6L	9.77	6T	23.53
6T	12.52	6L	1.77
7L	16.49	7T	15.25
7T	14.09	7L	14.10
8L	6.95	8T	4.32
8T	3.61	8L	3.41